ENVIRONMENT CANADA
ENVIRONMENTAL PROTECTION SERVICE

SHORELINE PROTECTION AND CLEAN-UP MANUAL

PORT OF VANCOUVER

DEPARTMENT OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
ENVIRONMENTAL EMERGENCY BRANCH
PACIFIC AND YUKON REGION

SHORELINE PROTECTION AND CLEAN-UP MANUAL
PORT OF VANCOUVER

REGIONAL PROGRAM REPORT 84-02

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PREAMBLE

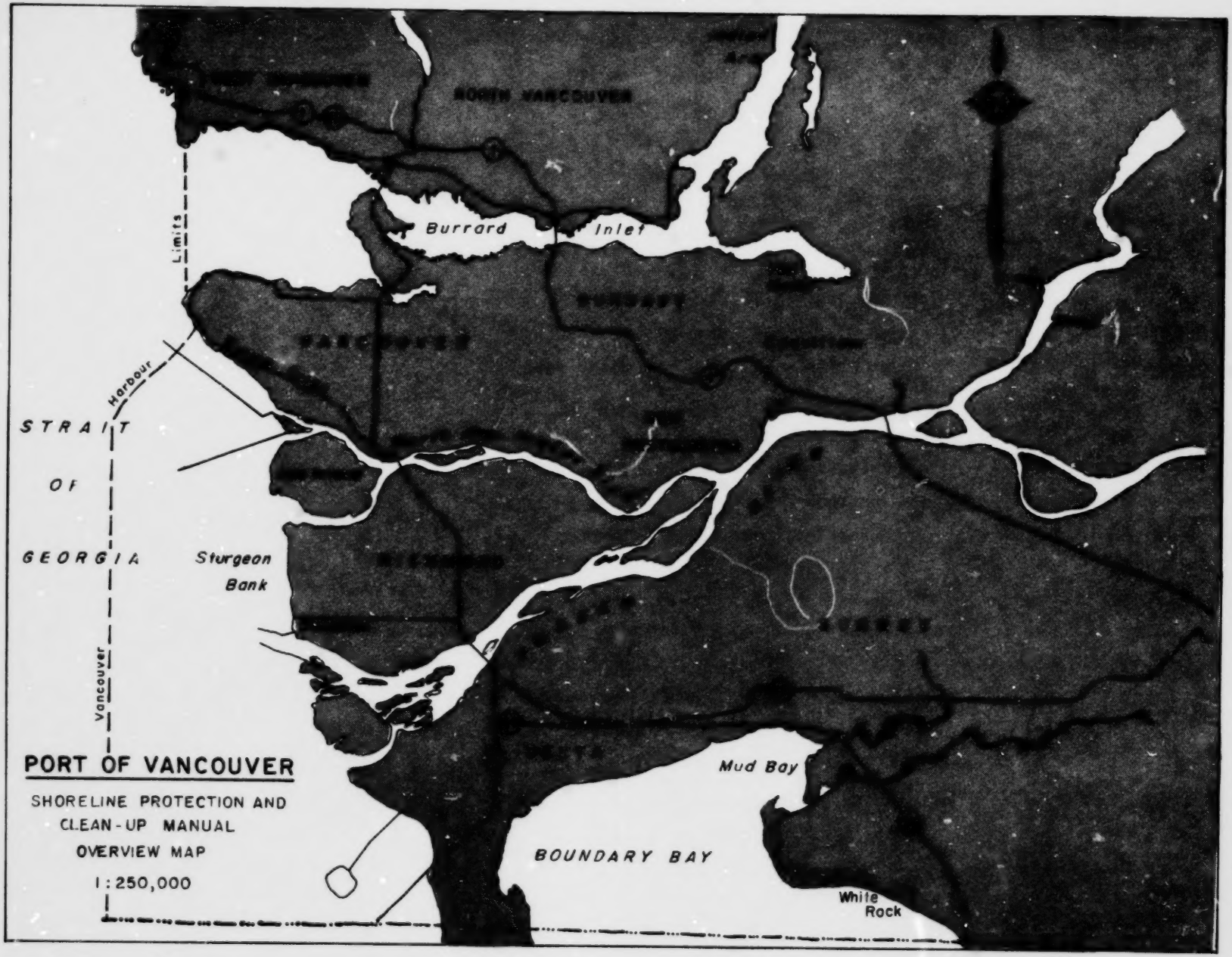
This manual was prepared by the Environmental Protection Service to augment contingency planning efforts conducted by industry and government in the Port of Vancouver. Vancouver has experienced many small and several large oil spills during the last decade and the experience gained in the control and clean-up of those spills has been distilled in this manual. The authors wish to thank the many experts in the field of oil spill countermeasures and those environmental agencies, in particular the Canadian Wildlife Service, the Department of Fisheries and Oceans, Ministry of Environment (B.C.), and the Canadian Coast Guard, which contributed to the compilation and review of this report. We also wish to express our gratitude to the British Columbia Petroleum Association and the Port of Vancouver for their support in this endeavour.

TABLE OF CONTENTS

		Page
PREAMBLE		i
TABLE OF CONTENTS		ii
	List of Figures	iii
	List of Tables	iv
1.0	INTRODUCTION	1
1.1	Format of the Manual	2
1.2	Biological Resources	2
1.3	Socio-Economic Resources	7
1.4	Physical Sensitivity	8
1.5	Access	8
1.6	Countermeasures	9
1.7	Acknowledgements	11
2.0	REGIONAL MAP SET	
	Point Atkinson to Boundary Bay	13
3.0	OPERATIONAL MAP SET	
3.1	West Vancouver and Point Grey	17
3.2	Vancouver Harbour and English Bay	23
3.2.1	Coal Harbour	31
3.2.2	False Creek	36
3.3	Deep Cove - Port Moody	38
3.3.1	Port Moody - Ioco	46
3.4	Indian Arm	49
3.5-3.7	Fraser River Estuary North Arm - Point Roberts	54
3.8	Point Roberts and Boundary Bay	64
3.9	Boundary Bay (east to Ocean Park)	70
3.10	Ocean Park to Peace Arch Park	74
4.0	SELECTED BIBLIOGRAPHY	77
5.0	APPENDIX	83

LIST OF FIGURES

Figure		Page
1	Overview Map	v
2	Regional Spill Strategy Map	12
3	Operational Map 1 - West Vancouver and Point Grey	16
4	Operational Map 2 - Vancouver Harbour	22
5	Tactical Map 2a - Coal Harbour	31
6	Tactical Map 2b - False Creek	35
7	Operational Map 3 - Deep Cove - Port Moody	39
8	Tactical Map 3a - Port Moody - Ioco	45
9	Operational Map 4 - Indian Arm	48
10	Operational Map 5 - North Arm and Middle Arm	53
11	Operational Map 6 - Fraser River	56
12	Operational Map 7 - Roberts Bank and Tsawwassen	58
13	Operational Map 8 - Point Roberts and Boundary Bay	63
14	Operational Map 9 - Boundary Bay to Mud Bay	69
15	Operational Map 10 - Ocean Park to Peace Arch Park	73


NORTH VANCOUVER
Burrard Inlet
Limits
Harbour
STRAIT
OF
GEORGIA
Sturgeon
Bank
Vancouver
Mud Bay
BOUNDARY BAY
White
Rock
PORT OF VANCOUVER
SHORELINE PROTECTION AND
CLEAN-UP MANUAL
OVERVIEW MAP
1:250,000

1.0 INTRODUCTION

The Port of Vancouver extends from the U.S. border north to Point Atkinson. All waters of Boundary Bay, the approaches to the Fraser River and Burrard Inlet are included in the area covered by this manual (Figure 1). Vessel traffic and other oil related marine activity brings the risk of oil spills very close to sensitive environmental resources. The purpose of this shoreline protection and cleanup manual is to identify the resources in the Port area and recommend methods by which they can be protected from oil spills or restored to original condition in the event of contamination.

The manual begins with an overview of the biological, physical and socio-economic resources of the area, emphasizing their sensitivity or vulnerability to oil spills. The sections following the overview are the working portion of the manual. They consist of a series of maps at various scales depicting: sensitive areas, access, logistics, boom placement locations, beach types and other pertinent information. Accompanying each map is a legend and text that further describe these features and the methods most appropriate for their protection and cleanup.

1.1 Format of the Manual

This manual is organized according to the format in the EPS report "Guide to the Preparation of Shoreline Protection and Clean-up Manuals". Figure 2 (page 11) presents a (1:250,000) map of the entire port on which highly sensitive areas and sites have been "flagged". These sites and areas are identified on the accompanying legend and a brief description of the principal values or resources at risk is provided. Further, the sites have been priorized to allow concentration of effort in the most sensitive areas in the event of a spill. Readers should also note that the Fraser River estuary is considered uniformly sensitive and no locations within it can be singled out for special attention.

Following the small-scale port map is a series of 1:50,000 scale maps intended as operational maps. These cover the entire port area in individual sections to provide detail on shoreline types, access, logistics, countermeasures and constraints. Each map is accompanied by a text elaborating the mapped features. In some instances sites of unusual significance such as False Creek are covered by a larger scale map to provide greater detail.

1.2 Biological Resources

The biological resources of Burrard Inlet and the Fraser Estuary combine both high intrinsic values with high consumptive and recreational utilization. The following summary highlights these resources, their habitat variability, and vulnerability to spills.

1.2.1 Fish and Shellfish. Oil spills can result in significant effects to coastal estuaries, nearshore waters, and shorelines. The Port of Vancouver and adjacent waters covered by this unusual encompasses an impressive length of shoreline. As well, the Fraser Estuary is the largest shallow water expanse on the entire west coast of B.C. It is in these type of habitats that the effects of oil spills tend to have the greatest impact.

In the subject area, the Fraser Estuary and its significant stocks of rearing juvenile chinook and chum salmon fry are particularly important. Other salmon fry also can be found in the Fraser Estuary but are transient and do not establish in rearing areas. Coho and chinook smolts and the juveniles of anadromous trout and char are also present in the estuary, foraging in various areas throught the year.

Young of the year salmonids are small and have limited ability to avoid contaminated waters. If fry successfully move to alternate habitat, survival or growth may be significantly reduced, due to poorer habitat quality. Thus, in the event of a spill there is potential for both direct (initial mortality) and indirect (reduced growth and survival) effects on salmonid populations. Conceivably with greater juvenile morality, adult stocks and the commercial fisheries could be affected.

Adult salmonids use the Fraser River as a migratory route to up-river spawning areas. Certain species and stocks also use the estuary as a staging area prior to river entry and upstream migration. However, unlike juveniles, adult salmonids use deeper water for both migration and staging and are therefore less likely to be affected by oil spills.

Regardless of the effects on juvenile and adult salmonids, the commercial fisheries on the Fraser estuary will be subjected to fouling of both nets and boats in the event of a spill.

Rearing and migrating juvenile salmonids and adult anadromous trout and char are also present in waters in the other areas of the port year round. All nearshore areas contain rearing fish from early spring through summer. Adults use the deeper waters of Burrard Inlet, Indian Arm and Point Roberts as migratory routes to natal streams.

Unlike salmonids, only small numbers of herring use the Burrard Inlet-Fraser Estuary area for reproduction. However, when adults enter shallow water such as Boundary Bay to spawn, and during subsequent egg and larval development, herring are particularly vulnerable to oil spills. Offshore of Sturgeon and Roberts Bank the concentration of juvenile herring can be quite high at certain times of the year.

Large populations of groundfish from a variety of species (starry flounder and staghorn sculpin are particularly abundant) inhabit the Fraser Estuary and similar areas in Burrard Inlet. Juveniles of all species would be vulnerable to the effects of a spill.

The impacts of oil spills on shellfish are not only determined by contaminant concentration and acute toxicity, but also by the duration of contamination. The type of substrate is important, particularly for bivalves; soft substrates can trap the oil, resulting in later recontamination. Conversely, high wave energy associated with rocky environments effectively dissipates oil more quickly.

Molluscs are sessile animals, cannot avoid local contamination, and are highly susceptible to all spills. Further, molluscs are indiscriminate filter feeders and ingested oil particles tend to anaesthetize important body parts, resulting in suspended growth or death. Sublethal effects to molluscs include long-term contamination and unsuitability as human food.

Adult crustacea, shrimp, and prawns, common in the deeper waters off Sturgeon and Roberts Banks are less vulnerable to oil spills. Their larval stages however, frequent shallow water, and their sensitivity would be high during a spill event. Crabs are considerably more vulnerable at all life stages because of their preference for shallow waters. The most sensitive period is March to June, when larvae from a large porportion of crustacea inhabit shallow waters.

In conclusion, the effects of oil spills on aquatic environments and organisms tend to be most pronounced in productive nearshore shallow water habitats. These contain large populations of sessile or relatively immobile organisms, and important planktonic communities that provide food for juvenile salmonids and other fishes rearing in these areas. Spill responses in these areas require prompt expedition and execution to protect fish and invertebrates and their habitats.

1.2.2 Birds. The Fraser Estuary ranks highly among the key sites for migratory birds along the B.C. Coast. Only one or two of the major seabird breeding colonies can match its importance. The Burrard Inlet area is also a significant area for seabirds but numbers in no way compare.

The Fraser Estuary is a winter and migratory stop for dabbling ducks, diving ducks, geese, divers, shorebirds and swans. The most vulnerable to oil would be the diving ducks and divers (loons, grebes, and cormorants). However, the numbers of dabbling ducks justify their greater prominence both in terms of conservation and recreation. Peak numbers in excess of 40,000 have been regularly reported. Shorebirds, though much less vulnerable to oilspills, pass through the estuary in much greater numbers: limited mark-recapture results indicate that over one million western sandpipers alone migrate through. Breeding activity is limited, and as a consequence it is not viewed as an important local life history event.

Birds are usually the most conspicuous casualties of oil spills. Because so many seabirds in cold water oceans spend most of their life swimming, contamination during a spill is more likely and subsequently, more threatening. What causes bird mortality is not always evident. Oiling is most lethai because its coating of the feathers and subsequent preening by the victim disrupts the fine structure of the feathers. This, rather than interference with the oil gland, forms points through which water can penetrate the feather structure and ultimately lead to extensive heat loss. The victim usually deteriorates and dies after several days. Complicating this process is ingestion of oil during the preening process. The toxic properties lead to severe intestinal infection coincident with hypothermia. (In warm water oceans, potential mortality is less because of the reduced temperature gradient.) Also, during the breeding season adults with oil on their breast and belly feathers can coat their own eggs thereby reducing hatching success.

1.2.3 Mammals. The Burrard Inlet-Fraser Estuary area is an important concentration area for harbour seals, California and Steller's sea lions, and killer whales. There are several important haul-out areas

for harbour seals on Sturgeon Bank, Roberts Bank, and Boundary Bay. Pupping occurs at these sites in late spring, and this clearly represents the most vulnerable period in terms of oil spills. In spring, sea lions concentrate in large numbers at the mouth of the Fraser River. It is a recent phenomenon, due to the expansion of sea lion populations on the coast. Increased utilization of the estuary by sea lions may continue, but there are no records of pupping to date. Killer whales (pods J and K) frequent this area, but are not considered vulnerable to oil spills in any way comparable with other mammalian fauna.

1.2.4 Vegetation. Estuarine macrophytes and eelgrass are important contributors to the nutrient regime of the Fraser Estuary, and provide both temporary and year round habitat for many organisms. These plants produce foods which are used extensively by migratory birds, ducks, and geese especially. They also function in the growth and stability of the banks.

Large macrophytes would be most vulnerable should oiling occur early in the growing season when root reserves are low. At other times of year energy stored in roots (rhizomes) provides partial protection from the effects of oil spills.

1.3 Socio-Economic Resources

The Port of Vancouver is famous for its beaches, foreshore parks, recreational waterways and natural areas. Business and industrial use of shorelines and waterways is an equally important feature. Oil spills can

impinge upon the use and viability of both interests and therefore must be handled to mitigate both economic and aesthetic losses. The 1:50,000 operational maps identify those concerns most evident in specific areas of the Port.

1.4 Physical Sensitivity

The Port of Vancouver has over 200 kilometres of coastline encompassing all varieties of beach from the flat muddy estuary of the Fraser River to the steep rock cliffs of Indian Arm. The 1:50,000 map series employs a coded description of the five major shoreline types found in the area. Knowledge of shoreline types will assist in determining which beaches to protect, which will self-clean and what techniques are required to clean those contaminated. Readers are invited to refer to the EPS publication "Guide to the Preparation of Shoreline Protection and Clean-up Manuals", for specific methods applicable to protection and clean-up. Several of these techniques are illustrated in the appendix to this manual. The text accompanying each 1:50,000 operational map provides additional guidance.

1.5 Access

Rapid marine and surface access to areas threatened with contamination is important if spill countermeasures are to succeed. The Port of Vancouver is fortunate in that the bulk of its shoreline apart from Indian Arm is readily accessible by land and sea. Manpower and equipment can therefore be deployed with relative ease and safety wherever spills threaten nearshore areas.

The 1:50,000 maps identify access points, staging areas, docks, float plane landing sites and other logistics aids. It is recommended that the manual be supplemented with a street map of the lower mainland so crews can be readily dispatched to an appropriate staging area. The nautical charts and topographic maps identified in map legends will also be invaluable as access aids.

1.6 Countermeasures

The 1:50,000 operational map series and text combine operational and tactical aspects of the oil spill response. Where additional detail is required, supplemental tactical maps of larger scale have been provided. The primary purpose of this series is to recommend countermeasures appropriate to the sites of concern identified in the 1:250,000 regional map. Countermeasures are discussed under three main headings; spill response, protection and clean-up.

Spill Response provides an overview of the threatened area. Response techniques, such as offshore containment and recovery, slick diversion, chemical dispersion and sacrificial beaching are discussed as possible first response alternatives. Their feasibility is extremely dependent on weather conditions, sea states and other unpredictable circumstances which cannot be pre-determined.

Protection is more specific in that it suggests techniques and operations which might mitigate contamination of specific shoreline areas. Some techniques, such as damming, and erecting earth works on beaches, have not been extensively tested and, in some circumstances, may have unacceptable impacts on the

environment. Their inclusion with other, more traditional protection techniques, is intended only to stimulate an innovative approach to the difficult problems which will likely confront response teams in the field. The main offshore booming tactics are shown in the appendix.

The third field of response activity discussed in the countermeasures section is that of oil spill clean-up. Should offshore containment and inshore protection fail to prevent contamination of shorelines, extensive efforts may be required to remove oil from the various beach types that occur in the study area. Clean-up operations may also necessitate a certain amount of rehabilitation if damage is severe. The manual emphasizes clean-up of those shorelines where contamination will directly affect biological and socio-economic resources, or where it will resist natural cleaning. It discusses shoreline character and offers suggestions on the most appropriate methods of clean-up for each type found in the study area. Several shoreline clean-up techniques mentioned in the text are also illustrated in the appendix. In many portions of this coast, manual clean-up may be impractical and possibly of greater impact on the environment than the effects of oil contamination. Areas where rapid self-cleaning is likely to occur have been identified in the text.

The subject of oil spill protection and clean-up is too extensive and complex for exhaustive treatment in a manual of this type. It is therefore anticipated that the user will have some familiarity with the subject. A select bibliography is provided at the end of the manual with some useful references on the protection and clean-up of shorelines.

1.7 Acknowledgements

This manual was prepared by the Environmental Emergency Branch, Environmental Protection Service in active cooperation with the Port of Vancouver and the British Columbia Petroleum Association. It is based on a format first devised by Woodward-Clyde Consultants Ltd., and subsequently modified. Ms. K. Simpson and Ms. N. McFadden were responsible for much of the data gathering and field work. Cartography was provided by L. Petrie and L. Pearson of the Environmental Protection Service. The manual was edited by Ian Robertson and G.E. Rosberg (Ian Robertson Consulting Ltd.). Reviews of early drafts were conducted by the Department of Fisheries and Oceans, Canadian Coast Guard, Port of Vancouver, Canadian Wildlife Service, Ministry of Environment and others. The manual was organized and typed by Ms. C. Petrino and Ms. P. Wakeman of the Environmental Protection Service.

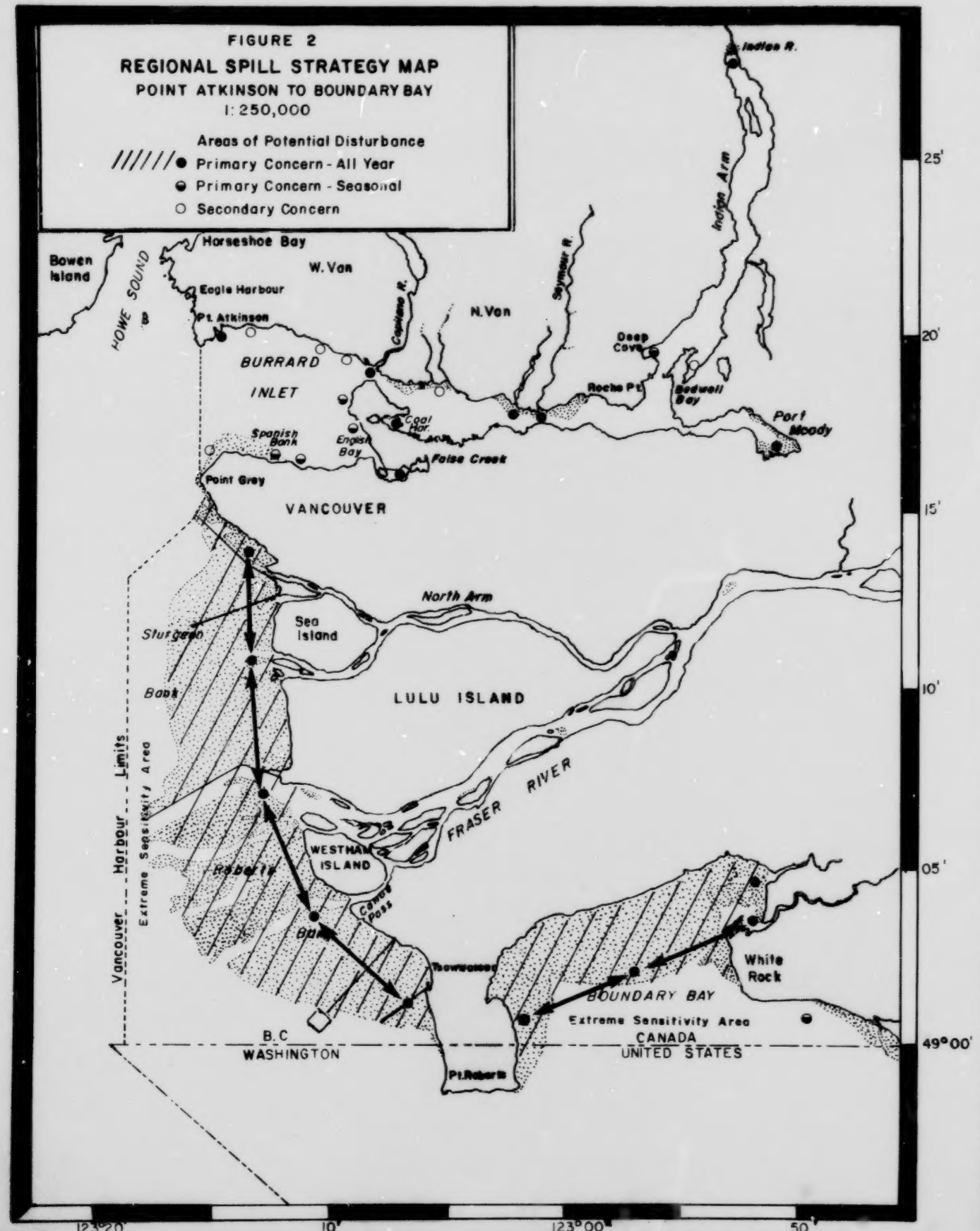


FIGURE 2
REGIONAL SPILL STRATEGY MAP
POINT ATKINSON TO BOUNDARY BAY
1:250,000
Areas of Potential Disturbance
Primary Concern - All Year
Primary Concern - Seasonal
Secondary Concern
Indian R.
Indian Arm
Seymour R.
Capilano R.
Horseshoe Bay
W. Van
Bowen Island
HOWE SOUND
Eagle Harbour
Pt. Atkinson
N. Van
Deep Cove
BURRARD INLET
Roche Pt.
Bedwell Bay
Port Moody
Coal Har.
Spanish Bank
English Bay
False Creek
Point Grey
VANCOUVER
North Arm
Sea Island
Sturgeon Bank
LULU ISLAND
FRASER RIVER
WESTHAM ISLAND
Roberts Bank
Canoe Pass
Vancouver Harbour Limits
Extreme Sensitivity Area
Tsawwassen
White Rock
BOUNDARY BAY
Extreme Sensitivity Area
B.C
WASHINGTON
CANADA
UNITED STATES
Pt. Roberts
25'
20'
15'
10'
05'
49°00'
123°20'
10'
123°00'
50'

REGIONAL SPILL STRATEGY MAP - POINT ATKINSON TO BOUNDARY BAY
1:250,000

Sites and Areas of Potential Human and/or Biological Disturbance

● 1. Caulfield Cove

- shellfish and crab
- harbour seals
- recreational area (marina and government dock)
- residential area
- waterfowl and diver habitat (October-April)

○ 2. Sandy Cove/West Bay/Dundarave/Ambleside

- shellfish and crabs
- herring spawn at Ambleside (spring)
- harbour seals (spring & summer)
- Pacific Environmental Institute - Fisheries Lab (West Bay)
- public beaches - high recreational value
- marinas/launch/ramps

◕ 3. Capilano River

- harbour seals (spring & summer)
- estuarine area
- Salmon Enhancement Program river
- large salmon runs
- recreational use
- waterfowl (year round)
- Indian reserve, parks residential area

○ 4. McKay Creek/Mosquito Creek Estuaries

- log booms, barge mooring

*

- marina - high recreational use
- small salmon runs

● 5. Lynn Creek

- estuary
- industry, marinas
- small salmon run

● 6. Seymour River/Maplewood Mud Flats and Estuary

- estuary - salt marsh
- high biological productivity
- waterfowl and divers (October-April)
- clam, crab and other shellfish
- boat building/barge moorages
- log booming, chemical plant
- Indian reserve
- large salmon run
- Salmonid Enhancement Program river

◒ 7. Deep Cove

- crabs and shellfish
- harbour seals
- waterfowl (October-April)
- scuba diving, beach activity
- boat ramp - public park, marinas

REGIONAL SPILL STRATEGY MAP - POINT ATKINSON TO BOUNDARY BAY
1:250,000

Sites and Areas of Potential Human and/or Biological Disturbance

● 8. Indian River

- estuarine area
- large salmon run
- log booming
- waterfowl (October-April)
- recreational area

○ 9. Bedwell Bay

- harbour seals
- crab
- eel grass beds
- boat moorage
- high recreational value
- water ski club
- residential area

● 10. Port Moody Arm

- mud flats and estuary
- harbour seals
- log booming
- waterfowl (October-April)
- shellfish - clams - mussels - crab
- small salmon runs

● 11. Vancouver Harbour

- divers and waterfowl (October-April)
- recreational area

● 12. Coal Harbour

- marina
- hotels and light industry
- mud flat area
- park water frontage
- shellfish - crabs
- waterfowl and divers (October-April)

● 13. False Creek

- salmon rearing pens
- extensive marinas
- Granville Public Market and Wharf
- residential, recreational area

◒ 14. Second/Third/English Bay Beaches

- Stanley Park seawall
- public swimming areas
- high use recreation and residential (English Bay)
- smelt spawn
- waterfowl (October-April)

◒ 15. Kitsilano Point/Jericho Beach/Spanish Bank

- public park, intense beach activity
- residential area
- Canadian Coast Guard Base (Kitsilano)
- shellfish, crab, smelt spawn
- waterfowl (October-April)

REGIONAL SPILL STRATEGY MAP - POINT ATKINSON TO BOUNDARY BAY
1:250,000

Sites and Areas of Potential Human and/or Biological Disturbance

○ 16. Point Grey/Wreck Beach

- public beach
- salmon rearing area
- smelt run

//////● 17. (A,B,C,D)- Fraser River Estuary - North Arm - Point Roberts

- large salmon run
- extensive estaury and marsh
- high biological productivity
- shore-birds, waterfowl and divers (year round)
- important salmon rearing and acclimation areas
- shellfish, crab, ground fish
- Reifel Bird Sanctuary - Tsawwassen Indian Reserve

● 18. Boundary Bay

- smelt run, herring spawn, ground fish
- salt marsh
- shellfish, crab
- recreational/residential area
- major concentrations of waterfowl, shorebirds and divers (year round)

● 19. Mud Bay/Nicomekl and Serpentine Rivers

- smelt/salmon runs
- estuarine marsh area
- waterfowl
- salmon acclimation area
- shellfish and crabs
- recreational area/marina

◒ 20. Semiahmoo Bay

- smelt run
- shellfish and crabs
- recreational/residential area
- waterfowl, shorebirds, and divers (year round)
- small salmon run

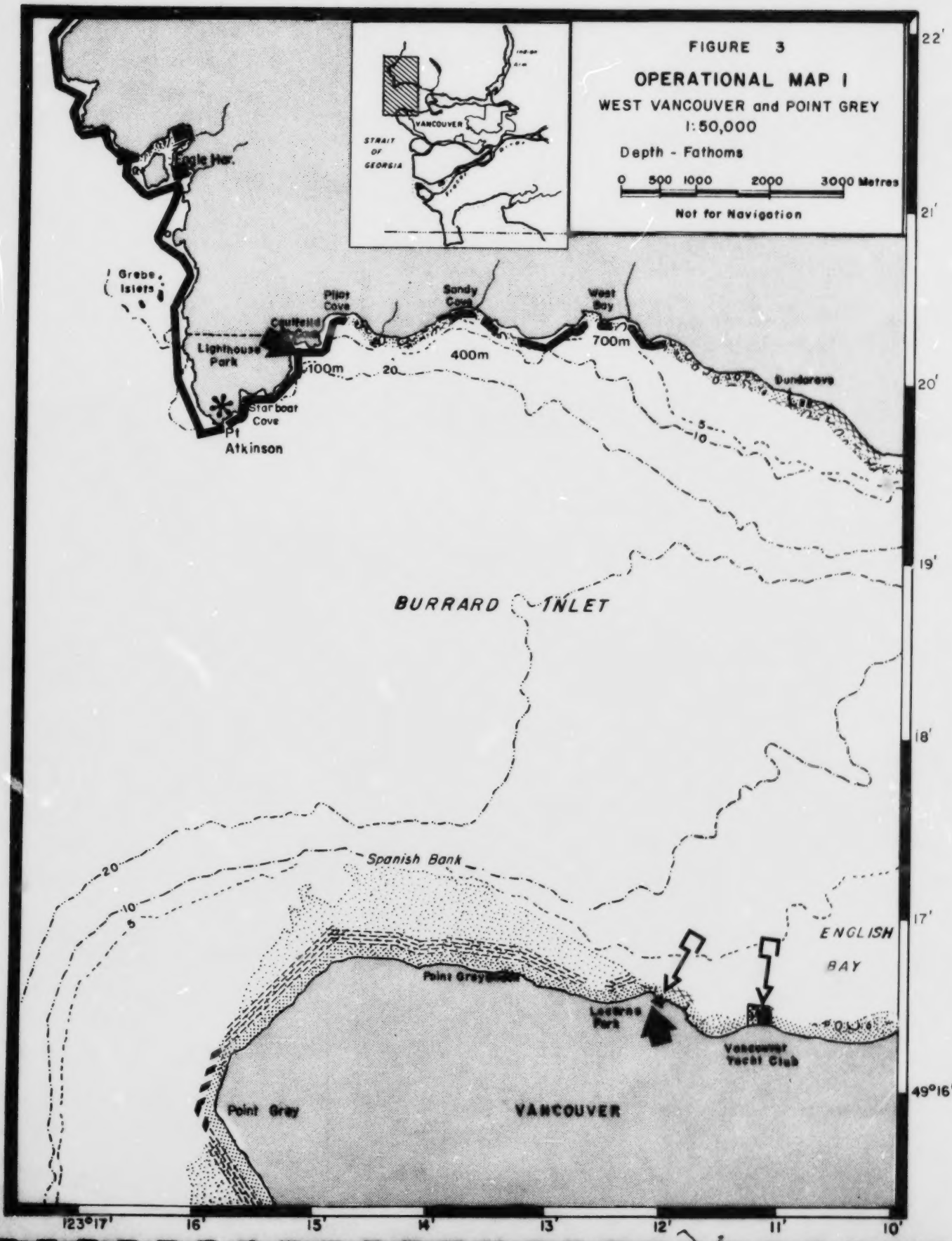


FIGURE 3
OPERATIONAL MAP I
WEST VANCOUVER and POINT GREY
1:50,000
Depth - Fathoms
0 500 1000 2000 3000 Metres
Not for Navigation
VANCOUVER
STRAIT OF GEORGIA
Eagle Har.
Grebe Islets
Pilot Cove
Sandy Cove
West Bay
Caulfeild
Lighthouse Park
100m
400m
700m
20
Dundarave
Starboat Cove
Pt Atkinson
5
10
BURRARD INLET
Spanish Bank
20
10
5
ENGLISH BAY
Point Grey
Locarno Park
Vancouver Yacht Club
Point Grey
VANCOUVER
22'
21'
20'
19'
18'
17'
49°16'
123°17'
16'
15'
14'
13'
12'
11'
10'

Operational Map 1 West Vancouver and Point Grey

Spill Response

Response in this area should concentrate on the containment and recovery of slicks within Burrard Inlet before they contact the West Vancouver and Point Grey shorelines. This is a highly visible, accessible and valuable stretch of coastline and thus would probably be a high priority clean-up area if contaminated. Caulfield Cove, Sandy Cove and West Bay on the West Vancouver shorefront and the Vancouver Yacht Club and Point Grey Beach on the Vancouver shorefront would be priority sites for both biological and economic reasons. The first line of protection should be the use of vessel controlled and containment booms and skimming operations offshore.

The main limitations to these operations would be high winds and waves. Also, heavy vessel traffic in and out of Vancouver Harbour and English Bay could interfere with clean-up operations. Vessel Traffic Management would assist by directing such traffic away from clean-up operations.

In the event that slicks threaten shorelines, efforts should be made to divert them onto 'sacrificial' beaches. Several considerations should govern such a clean-up tactic. First, such beaches should have relatively low ecological value. Second, they should be composed of materials which are easy to clean. A government ecologist should take part in such decisions. Generally, fine grained sandy beaches are preferable as they can be cleaned more effectively

than coarse grained beaches or rock faces and are more easily replaced with similar sediments. Dundarave beach on the West Vancouver shorefront and Locarno beach on the Point Grey waterfront are prime sites for sacrificial beaches because of accessibility, location, and sediment type. In the summer months the public beaches of both West Vancouver and Point Grey are used extensively. As a result, concentration on protection rather than clean-up may be warranted to a greater degree at this time of year.

Protection

The open waters of Burrard Inlet comprise most of the area of this operational map. It is here that most of the initial containment and recovery operations should be concentrated, assuming an open water source of oil. Under favorable wind and wave conditions and deploying booms and skimmers designed for open water conditions, considerable success is possible.

Closer to shore, several areas would require protection using exclusion or diverting booms. Approximately 100 meters of boom would protect the entrance to Caulfield Cove, although occasional strong south-westerly winds may create large swells, impeding boom deployment and effectiveness. Other West Vancouver coves are less sensitive although they are recreational and residential areas. Diversion booming of slicks past these areas onto sacrificial beaches may be a successful alternative depending on tide and sea conditions. Dundarave beach with its easily accessible, fine grained sand seems a logical site. East of Dundarave Pier, the West Vancouver seawall should be relatively easy to clean.

On the Point Grey side of Burrard Inlet it is advisable that the area of the Royal Vancouver Yacht Club be protected to avoid the potential high cost of boat clean-up and contamination of a high use recreational

area. Exclusion booms stationed outside the yacht club entrance may trap incoming oil before it strands on docks, boats etc. On a smaller scale, the use of absorbents (pads, absorbent booms, mats, etc.) is a protective measure that can be instigated by boat owners and/or wharfingers. A major effort would be required to persuade boat owners to forego use of their vessels until booms are removed.

Clean-up

The greatest proportion of shoreline in this area is composed of sand and mixed sediment beaches (Figure 3). Thus, clean-up of the major beaches in this area, Point Grey beach and Dundarave beach, would favor trench and dyke emplacements (the ditch-dyke system) if oiled. These should be constructed at the mid-tidal areas and oil diverted here. Lining these trenches with polyethylene should limit oil penetration into coarser sediments. Back up equipment in the form of pumps, tank trucks, and oily water separators should be made available. Because of the length of beach involved, it would be unrealistic to expect the completion of mid-tidal ditch-dyke emplacements, in all areas threatened. Therefore, an alternate or back-up technique would be to make exstensive use of sorbent materials. These could then be recovered using appropriate combinations of motor graders, elevating scrapers, front-end loaders, bulldozers, backhoes, draglines or clamshells.

The other major shoreline type in this area is bedrock cliff, all of it along the West Vancouver shoreline. It has a relatively low energy wave environment, suitable to hydroblasting, steam cleaning, sandblasting and manual scraping methods, with sorbents providing the recovery.

Access

Much of the West Vancouver shoreline west of Dundarave is formed by bedrock cliff (Figure 3). Access to the shoreline is restricted by private property and narrow roads perpendicular, rather than parallel, to the shore. Access is much better in the coves (e.g. Caulfield Cove , Sandy Cove). As a result, a significant amount of the clean-up would have to be coordinated from the water. Caulfield Cove houses temporary moorages and a government wharf. Private moorings buoys and rafts are anchored along the West Vancouver shorefront, primarily in the summer. The Pacific Environmental Institute situated west of Sandy Cove has docking, launching and storage facilities with a winch available for loading equipment and launching small boats. The dock is ideally suited for larger vessels and is spacious enough to land a helicopter. Dundarave boat jetty has tie-up facilities for small to medium-sized craft. West Bay has a boat launching ramp.

In Point Grey, the headlands of Spanish Banks and around Point Grey have steep sandstone cliffs which make the shoreline inaccessible from above but vehicles can easily access the beach from Point Grey Road. Between Point Grey and Locarno Beach, boat access is not good due to strong tidal currents, submerged rocks and shallow sand or mud banks which extend out at least one kilometre in places. A public fishing and recreational pier is situated about 0.3 kilometers NW of Jericho Beach, and the Royal Vancouver Yacht Club is also close by, east of the beach. Some docking facilites are available here with owner permission. For more precise information, refer to appropriate hydrographic charts, topographical and road maps.

Biological Resources

The steep rocky shoreline of Lighthouse Park and offshore islands, particularly Passage Island, provide nesting habitat for modest populations of gulls and cormorants. Observations of mallards, mergansers, and

murrelets with young indicate limited nesting. Winter diving duck and diver populations are considerable. Most ducks are distributed close to shore, whereas some of the divers, particulary western grebes are found in the open waters of the Burrard Inlet.

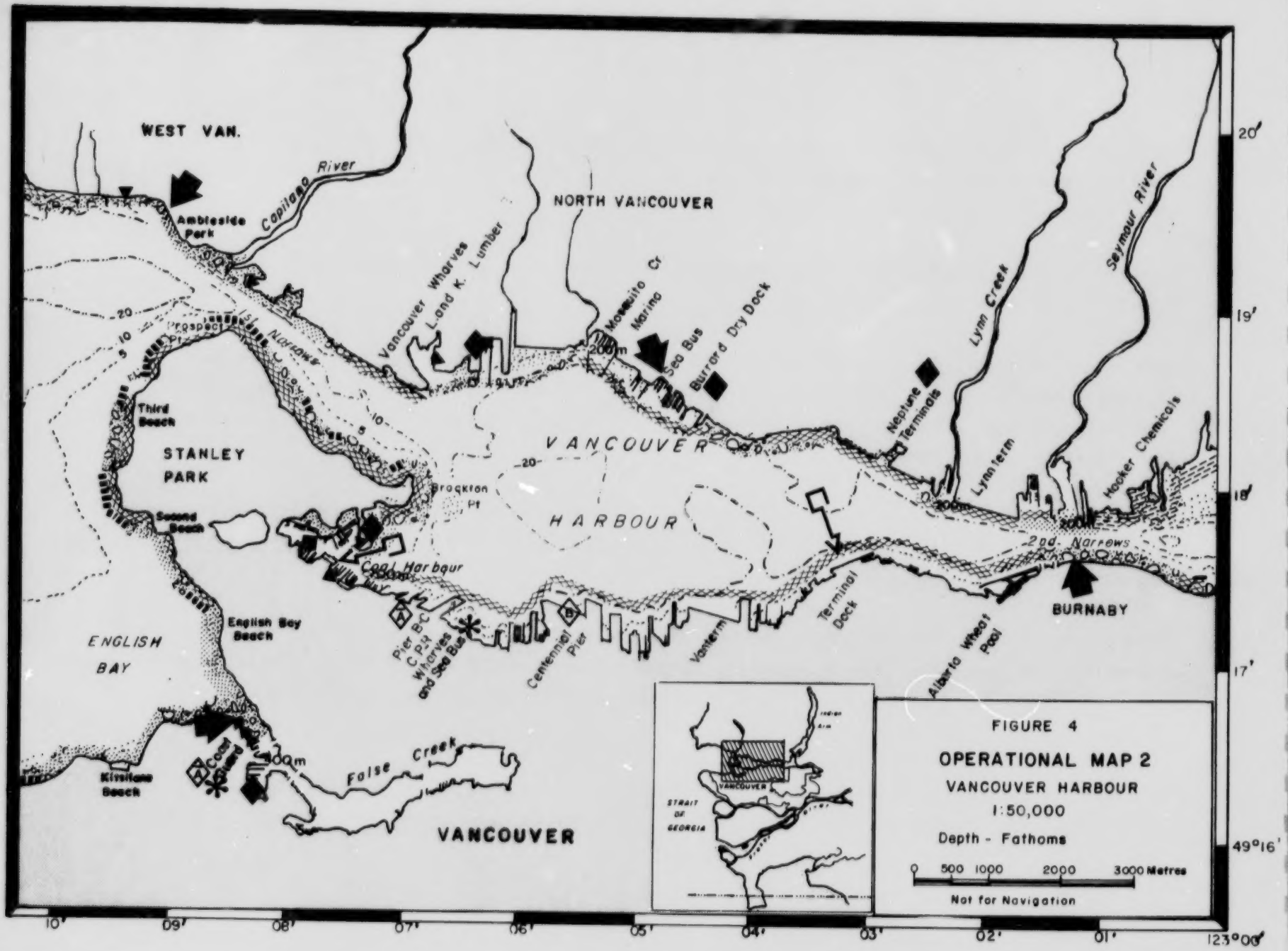
Harbour seals are commonly seen in the summer and fall along ther West Vancouver shoreline, often sheltering in areas such as Sandy Cove.

The waters off Lighthouse Park afford good fishing and are abundant in salmon, herring, and other species (lingcod, rockfish etc.). Juvenile salmon (chinook, coho, and chum) utilize the West Vancouver waters for rearing, with highest numbers from April through August. They are strongly oriented to shoreline areas and are vulnerable to oil contamination.

Across Burrard Inlet, similar assemblages of fish, invertebrates and wildlife populations occur. Species differences reflect obvious habitat differences: rock and cobble shorelines along West Vancouver, sand and mud along the Spanish Banks area of Vancouver.

Fishery sensitivities here are similar as the extensive littoral zone provides habitat for juvenile salmonids. The banks also provide important habitat for various flatfish and smelt in shallow waters where their vulnerability to oil is high. Crabs in shallow water and shrimp in deeper water are also fairly abundant.

The tidal flats attract a wide variety of migrant shorebirds during July to October. Subsequently, an annual influx of diving ducks and seabirds maintains significant populations from November to April.


WEST VAN.
Capilano River
Ambleside Park
NORTH VANCOUVER
Vancouver Wharves
Land K. Lumber
Mosquito Cr Marina
Sea Bus
Burrard Dry Dock
Neptune Terminals
Lynn Creek
Seymour River
Lynnterm
Hooker Chemicals
Prospect Pt
Lions Gate Bridge
Third Beach
STANLEY PARK
Second Beach
Brockton Pt
VANCOUVER HARBOUR
Coal Harbour
2nd Narrows
BURNABY
Terminal Dock
Vanterm
Centennial Pier
Pier BC C.P.R. Wharves and Sea Bus
English Bay Beach
ENGLISH BAY
Alberta Wheat Pool
Kitsilano Beach
False Creek
VANCOUVER
STRAIT OF GEORGIA
FIGURE 4
OPERATIONAL MAP 2
VANCOUVER HARBOUR
1:50,000
Depth - Fathoms
0 500 1000 2000 3000 Metres
Not for Navigation
20'
19'
18'
17'
49°16'
10'
09'
08'
07'
06'
05'
04'
03'
02'
01'
123°00'

Legend

Shoreline Classification

Bedrock cliff
Rock platform
Mixed sediment
Sand
Tidal flats
Sequence of rocky headlands and pocket beaches
Man-made

Access

Docking facility
Launch ramp
Staging area
Float plane landing
Helicopter pad
Marine Access

Resource Material

Hydro charts 3482, 3483
Topo maps 92 G/6
Video tape 5

Countermeasures

Oil spill package
Boom deployment metres (m)
Sacrificial beach
Oil collection point
Oil burning site
Oil disposal site

Operational Map 2 Vancouver Harbour and English Bay

Spill Response

Offshore response should concentrate on containment and recovery of free-floating slicks before they enter False Creek and Coal Harbour. If a spill occurs outside the main harbour, diversion of oil to sacrificial beaches or quiescent areas should be attempted. Currents in excess of five knots and tide rips may make containment and recovery impractical and possibly dangerous in the vicinity of First Narrows and Second Narrows. Opposing wind and swell movements in this area often create turbulent sea conditions that could make deployment of oil spill equipment difficult. Heavy vessel traffic may also hamper clean-up operations. As this entire area has a predominantly low wave environment, the most feasible areas at which to concentrate clean-up operations will be in the open waters of the Harbour. Outside of the First Narrows it may be prudent to direct oil toward highly accessible sand beaches such as Ambleside beach in West Vancouver. Fine-grained sandy beaches are preferable as they can be cleaned more effectively than coarse grained beaches or rock faces.

Protection

Tidal currents in First and Second Narrows would largely limit the effectiveness of open water containment and recovery operations around the estuaries of the Capilano River, Lynn Creek and the Seymour River. In particular, the Capilano River Estuary warrants a high protection priority. Diversion of oil onto adjacent Ambleside Beach employing diversion or cascading boom deployments may

be necessary provided a thorough clean-up follows. Coal Harbour represents another high priority area. Although fairly wide, the harbour is calm with very little current, and booming should be possible. Under low wind conditions exclusion booms should be stationed at the entrance to Coal Harbour to trap incoming slicks before they strand ashore or foul moored vessels.

Industrial North Vancouver and most of the Vancouver waterfront exhibits a variety of docks and piers. Although the impact on man-made shorelines may not be as great as on natural shorelines, clean-up is required to avoid contamination of adjacent sites. The main strategy here should be to contain and recover oil in the semi-protected waters of inner Vancouver Harbour prior to it reaching the shoreline. The effectiveness of large skimming devices will be important in determining the success of open water containment strategies.

In addition to Coal Harbour already mentioned, special protection should be provided to the Mosquito Creek area, where a large marina should be boomed. Lynn Creek, and Seymour River also warrant protection by diversion or exclusion booms.

Outside Vancouver Harbour proper, the entrance to False Creek at the south-east of English Bay would require booming if threatened by oil. Stretching approximately 300 meters of boom across the entrance, with sufficient supporting booms would offer a good chance of excluding most oil. Booming would interfere with vessel traffic using False Creek. However, successfully sealing False Creek would eliminate the need to clean up marinas, complex shorelines, and stored log booms. Oil trapped by such booms could be skimmed or pumped off here, or could be diverted either to English Bay beach or to Kitsilano Pt. English Bay would appear to be the best choice with its sandy shoreline. The Vancouver Aquatic Centre and the Stanley Park Public Aquarium should be advised to moniter salt-water intakes for contamination.

Clean-up

All the shoreline types differentiated in the manual are found in Vancouver Harbour. Man-made structures in the form of wharves, jetties and pedestrian seawalks are the most conspicuous. Several strategies are available to the on-scene commander. High temperature hydroblasting and steam cleaning would remove considerable oil from shoreline structures. Where there are large numbers of attached organisms low temperature flushing, manual scraping and wiping with sorbents is preferable.
Floating docks are fairly simple to approach, but access underneath piers and wharves that rest on pilings is limited. Oil can stay trapped under docks for long periods with possible long-term repercussions to organisms inhabiting these areas. Therefore, the local on-scene-commander must expect such clean-up procedures to be labour intensive and time consuming.

The most sensitive areas ecologically are the Capilano River Estuary, the Seymour-Maplewood Mud Flats, Coal Harbour, False Creek, and Stanley Park. In mud flat areas such as the Seymour-Maplewood Estuary and Coal Harbour, light flushing with water is the preferable technique. Excess foot and vehicular traffic can compound the damage to oiled mud flats. Oil is easily mixed with mud particles and is virtually impossible to remove. Thus, an environmental supervisor should be available for advice on this type of clean-up. Capilano River and Coal Harbour are low energy environments where weathering and self cleaning processes would be slow, hence the necessity for clean-up. Should the marsh in the lower Capilano become oiled, low pressure flushing on an ebbing tide could direct oil to recovery operations downstream. If the oiling is sufficiently severe, burning oiled vegetation may have to be considered, following consultation with the appropriate resource agencies.

Stanley Park's shoreline is a mixture of sand, mixed sediment, and protruding bedrock. The shoreline is readily accessible. Low pressure flushing may remove some contamination, however, heavier concentrations of oil may necessitate local excavation of sediments for cleaning and replacement.

Good road access and beach equipment mobility make mechanical operations feasible at all but the highest tides. Cleaning of bedrock areas may be restricted to water and steam blasting and to manual scraping. Sand-blasting or steam-cleaning are alternatives requiring more caution, as well as acceptance by trained environmental personnel.

Oil contamination to Second and Third beaches as well as English Bay Beach and Kitsilano Beach would involve the following response. In all cases considerable effort can be saved by applying sorbent materials prior to the oil reaching the beach. Another preparatory technique is the ditch-dyke system, which prevents oil from reaching upper inter-tidal areas and concentrates oil in trenches where it can be pumped away. Subsequently, graders and elevating scrapers can pile oiled sand into windrows, which can then be removed by scrapers or front end loaders for cleaning or disposal. Removed sediments must be replaced by similar material. Because of re-contamination from other sources, beaches should not be cleaned until the risk of further oiling has passed. It is therefore important when beach cleaning priorities are established, they are ordered in such a way that re-contamination is minimized.

Mixed sediment shorelines exist in various parts of the Vancouver Harbour area (Figure 4). Many of these are in fact coarse mixed sediments, such as at the mouth of the Capilano River and around Stanley Park. If oiling has not been severe, low pressure water flushing may suffice to remove the bulk of the contamination from these coarse sediment beaches. The only feasible alternative for cleaning heavily oiled beaches of

this type is to remove contaminated sediments with graders, clam shells and front end loaders. The technique may cause disruption to beach stability and have long term consequences for the local ecosystem. Thus, limiting clean-up to low pressure flushing may be the best environmental strategy. In any event, excavated beach sediments should be cleaned and restored, or replaced with similar clean material. It should be emphasized that any operation of this type should be performed under the guidance of engineers, biologists, and geomorphologists to ensure that environmental impact is minimized.

If False Creek is not boomed, or a spill occurs within its waters, appropriate measures must be taken to remove surface oil using containment booms, skimmers, and sorbents. Oil contacting the boats and docks would present a major clean-up challenge. As this is a popular area there would probably be public pressure to have it cleaned quickly.

Access

Access to shorelines throughout this area is good but permission from private owners may be necessary. Although much of the North and South shore waterfront is industrial, there should be no difficulty in attaining access. There are boat launching areas to the west of Ambleside Beach, on the east side of the Capilano River, at Mosquito Creek Marina, in Coal Harbour, beside the Canadian Coast Guard Station on Kitsilano Point and in False Creek. There are also numerous docking facilities throughout the Port of Vancouver as well as mooring buoys for small and large craft. Sea planes can be landed in most of the area under the right conditions and there is regular sea plane service in Coal Harbour. Helicopters can land at most beach sites and official helicopter pads are located at Point Atkinson lighthouse, beside Park Royal in West Vancouver, Brockton Point in Stanley Park and at the Kitsilano Base Coast Guard Station.

Road access to almost all areas concerned is good with the exception of cliff areas in Stanley Park. The shoreline of Stanley Park is partly accessible to vehicles. Dundarave Beach in West Vancouver, Ambleside beach, parts of the Seymour River shoreline, parts of Coal Harbour, Stanley Park, Third, Second, English Bay Beach, and Kitsilano Beach, all provide good traction for clean-up equipment.

These areas are also accessible by boat. Although weather rarely impedes boat traffic, special navigational care must be taken as there are many obscure rocks and currents in certain parts of the Burrard Inlet/Vancouver Harbour area. Nautical charts are required.

Biological Resources

Biological Resources in the Burrard Inlet - Vancouver Harbour area are abundant and diverse. Marine birds are plentiful most of the year. These include loons, grebes, cormorants, geese, ducks, gulls, alcids, and herons. Other birds utilizing the marine area include eagles and osprey.

The Capilano River houses a major hatchery as part of the federal Salmon Enhancement Program. Salmon and trout are spawned and reared in the river and/or the hatchery all year round. The river has a major coho population and chinook, pink and chum and steelhead runs. Waterfowl, gulls and shorebirds are plentiful year round. The river has heavy recreational use year round, with Ambleside Park on one side of the river, a trailer park on the other. It is also a popular fishing area. Populations of shellfish, primarily mussels, are abundant off the mouth.

Mosquito Creek also has a high recreational value, including a marina used year round. It has a significant shellfish population and wildlife, such as diving ducks, dabbling ducks, gulls, and harbour seals occurring during most of the year. There is also a small Coho run. Mosquito Creek has a small estuary and mud flat area.

Lynn Creek also has a small estuary, where waterfowl, divers and shorebirds congregate mainly in the winter months. Gulls, of course, are present year round. It has a shellfish population consisting mainly of mussels and clams. There is also a marina, which is used recreationally year round.

Seymour River salmon populations have been enhanced and its productive estuary supports juvenile salmon in spring and summer, waterfowl and divers in the winter primarily. Harbour seals are often seen in the summer and fall. There is also log booming and storage in the area year round. The Seymour Mudflats extend onto the Maplewood Mudflats, a very important and productive estuarine-salt marsh area.

Coal Harbour supports large numbers of waterfowl, divers and gulls primarily in the fall and winter. Harbour seals are often seen in the spring and summer months. It is a highly visible area, well used in terms of both recreation and commerce. A major hotel complex overlooks the area and a large marina is situated within it. It is also the home of the Vancouver Rowing Club and Sea Cadet Academy.

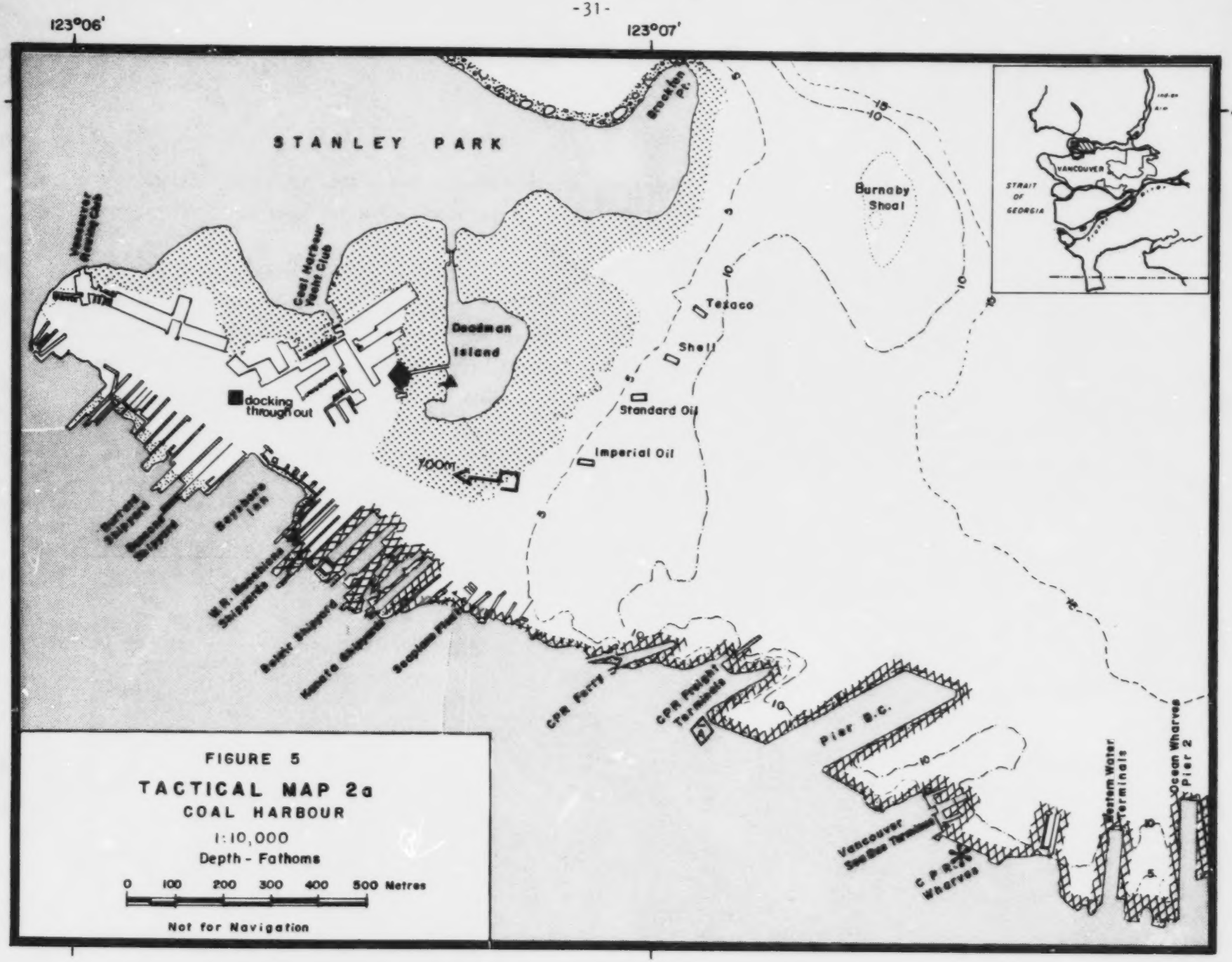
The shoreline surrounding Stanley Park has a large waterfowl and diver population primarily from October to May. It provides protected habitat for many species, including a large Canada Goose population. The beaches along this area and into the entrance of False Creek are occasional herring spawning grounds.

They are also high use recreational areas in all seasons except winter. Low tides frequently attract school and natural history tours to the rich intertidal fauna of these well flushed waters.

False Creek may be best known for its seapen rearing of salmon as part of a salmonid enchancement project which attracts children to fish in the Creek. Until recently False Creek supported a considerable amount of industry, but its character has changed dramatically. Much of the industry has been replaced with a large residential area on the south shore, and major recreational sites (marina, large stadium) along the north shore. Waterfowl and divers can be seen most of the year, plus occasional harbour seals.

Kitsilano Point has a small herring spawn, is a public park and so is well used year round especially in the summer.

In summary, areas of prime ecological importance are the Capilano River, Seymour River, Coal Harbour, False Creek, and the waters surrounding Stanley Park.


123°06'
123°07'
49°18'
STANLEY PARK
Brockton Pt.
Burnaby Shoal
Coal Harbour Yacht Club
Deadman Island
docking through out
100m
Texaco
Shell
Standard Oil
Imperial Oil
CPR Ferry
CPR Freight Terminals
Pier B.C.
Vancouver Sea Bus Terminal
C P R Wharves
Western Water Terminals
Ocean Wharves Pier 2
VANCOUVER
STRAIT OF GEORGIA
FIGURE 5
TACTICAL MAP 2a
COAL HARBOUR
1:10,000
Depth - Fathoms
0 100 200 300 400 500 Metres
Not for Navigation

Legend

Shoreline Classification

Bedrock cliff
Rock platform
Mixed sediment
Sand
Tidal flats
Sequence of rocky headlands and pocket beaches
Man-made

Access

Docking facility
Launch ramp
Staging area
Float plane landing
Helicopter pad
Marine Access

Resource Material

Hydro charts 3482
Topo maps 92 G/6
Video tape 5

Countermeasures

Oil spill package
Boom deployment metres (m)
Sacrificial beach
Oil collection point
Oil burning site
Oil disposal site

Tactical Map 2A Coal Harbour

Protection

The waters of Coal Harbour are already at risk due to proximity to major industrial areas of the port. There are four floating gas stations at the mouth of Coal Harbour and fairly concentrated industry on the south shore. Many seaplanes, ships, and barges use the harbour every day.

During ebb tide any oil within Vancouver Harbour would be flushed into Coal Harbour or deposited at the eddy line as the current flows northwest along Brockton Point. The shoreline here consists of very fine silt or mud with larger cobble stone sediments on the surface. As a result, it would be difficult to clean (the oil would be deep in the sediments) and difficult to replace. The rest of the shoreline is covered by docks and floats which are also difficult to clean. Oil tends to accumulate underneath them and, if left uncleaned, becomes a source of future re-contamination.

The velocity of the currents in Coal Harbour seldom exceed 0.5 knots. Thus, deployment of a boom across the mouth of the harbour should successfully contain oil. Approximately 700 meters of boom deployed between Deadman Island and the seaplane floats should protect the harbour entrance. Backup booms would be required. Booming would interfere with boat traffic and some monitoring would be required to restrict boat access and to ensure the boom is not damaged. Weather would rarely be a factor that interferes with operations in this area.

If oil necessitates diversion, the area on the south-east side of Brockton Point

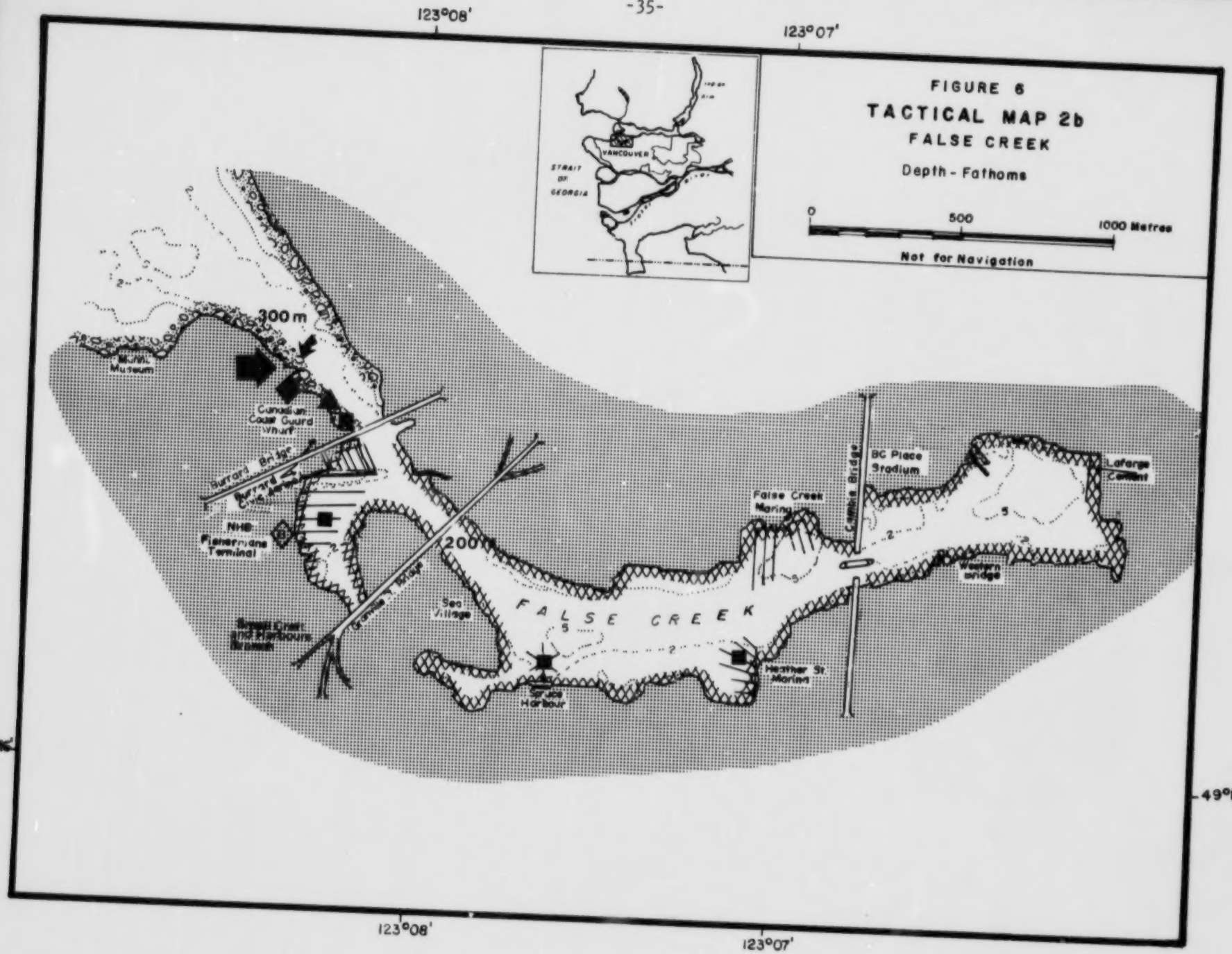
may function as a sacrificial beach. This beach is not optimally suited for either natural or manual clean-up, but is preferable to contamination of Coal Harbour. The area should be prepared in advance to minimize contamination. Trenches and dyke emplacements should be situated in mid-tidal areas and sufficient pumps, tank trucks and oil/water separators should be available to cope with oil coming ashore.

Clean-up

Clean-up of the mixed sediment beaches of Coal Harbour could be a difficult operation. Oil would tend to penetrate through the coarser sediment into underlying fine sediments. Wave or wash activity (even rain) would accelerate this process. Where the beach is not exposed to wave energy, as along the south-east side of Brockton Point to Deadman Island, and certainly within Coal Harbour proper, oil would persist for an inordinate period, both on the surface of exposed rocks and to the depths of penetration.

Low pressure flushing would remove part of the contamination from mixed sediment beaches. If this tactic is coordinated by skimming operations to collect the oil it may be possible to avoid the only real alternatives - removing the contaminated sediments or allow self-cleaning. Bulldozers, clam shells and front end loaders could be used to remove contaminated sediments. This technique could, however, cause severe disruption to beach stability and could have long term consequences for the local ecosystem. Thus, excavated beach sediments removed for cleaning would have to be restored, or replaced with similar material. In the case of Coal Harbour it would be extremely difficult to replace the substrate formed by years of silt deposition. An operation of this type would be undertaken only after engineers, biologists and geomorphologists have evaluated the environmental costs and benefits.

There would be some difficulty in cleaning floats and docks within the harbour as oil tends to accumulate underneath such structures. High pressure flushing would suffice to clean the outside of both docks and boats. A supply of absorbant materials will have to be made available to place under docks and around boats to prevent recontamination. Care must be taken during flushing that protective measures, such as containment booms around the clean-up site, prevent recontamination.


123°08'
123°07'
VANCOUVER
STRAIT OF GEORGIA
FIGURE 6
TACTICAL MAP 2b
FALSE CREEK
Depth - Fathoms
0
500
1000 Metres
Not for Navigation
300 m
200
Burrard Bridge
Granville Bridge
Cambie Bridge
BC Place Stadium
Lafarge Cement
False Creek Marina
Western Bridge
Sea Village
FALSE CREEK
Heather St. Marina
Granville Island
49°16'

Legend

Shoreline Classification

Bedrock cliff
Rock platform
Mixed sediment
Sand
Tidal flats
Sequence of rocky headlands and pocket beaches
Man-made

Access

Docking facility
Launch ramp
Staging area
Float plane landing
Helicopter pad
Marine Access

Resource Material

Hydro charts 3482
Topo maps 92 G/6
Video tape 4

Countermeasures

Oil spill package
Boom deployment metres (m)
Sacrificial beach
Oil collection point
Oil burning site
Oil disposal site

Tactical Map 2-B False Creek

Protection

The entrance to False Creek forms a fairly confined channel, the narrowest point located directly below the Burrard Bridge. If an oil spill threatened False Creek from the outside a containment boom could be placed across the entrance or between the Kitsilano Coast Guard Base and the Vancouver Aquatic Center. A minimum of 300 meters of boom should effectively protect the entrance into False Creek, but backup booms would be desireable. It is not recommended the boom be placed south of the Kitsilano Coast Guard Base (under the Burrard Street Bridge) as the National Harbours Board's fishermens terminal is located between there and the Granville Street Bridge. Because vessel movement into and out of False Creek is heavy, it would be difficult to completely stem this traffic. Thus, if oil approaches the protective booms at its entrance, some oil penetration into False Creek would likely result. The second step, therefore, is to protect the marinas by placing booms around their perimeters.

Clean-up

The shoreline of False Creek is mostly man-made or contains mixed sediment with local pocket areas of finer material. Removal of oil from this environment may be accomplished best by high to low pressure hydroblasting coordinated with oil skimming operations. The muddy areas at the head of False Creek are not highly sensitive, thus cleanup using draglines or clamshells plus manual labor would

not cause as much damage as in a more sensitive mud flat. Log booms stored in False Creek would trap oil if contaminated. This can be removed during de-barking process, but care must be taken to collect and recover oil and debris. This concern could be eliminated if containment booms were available to protect the logs.

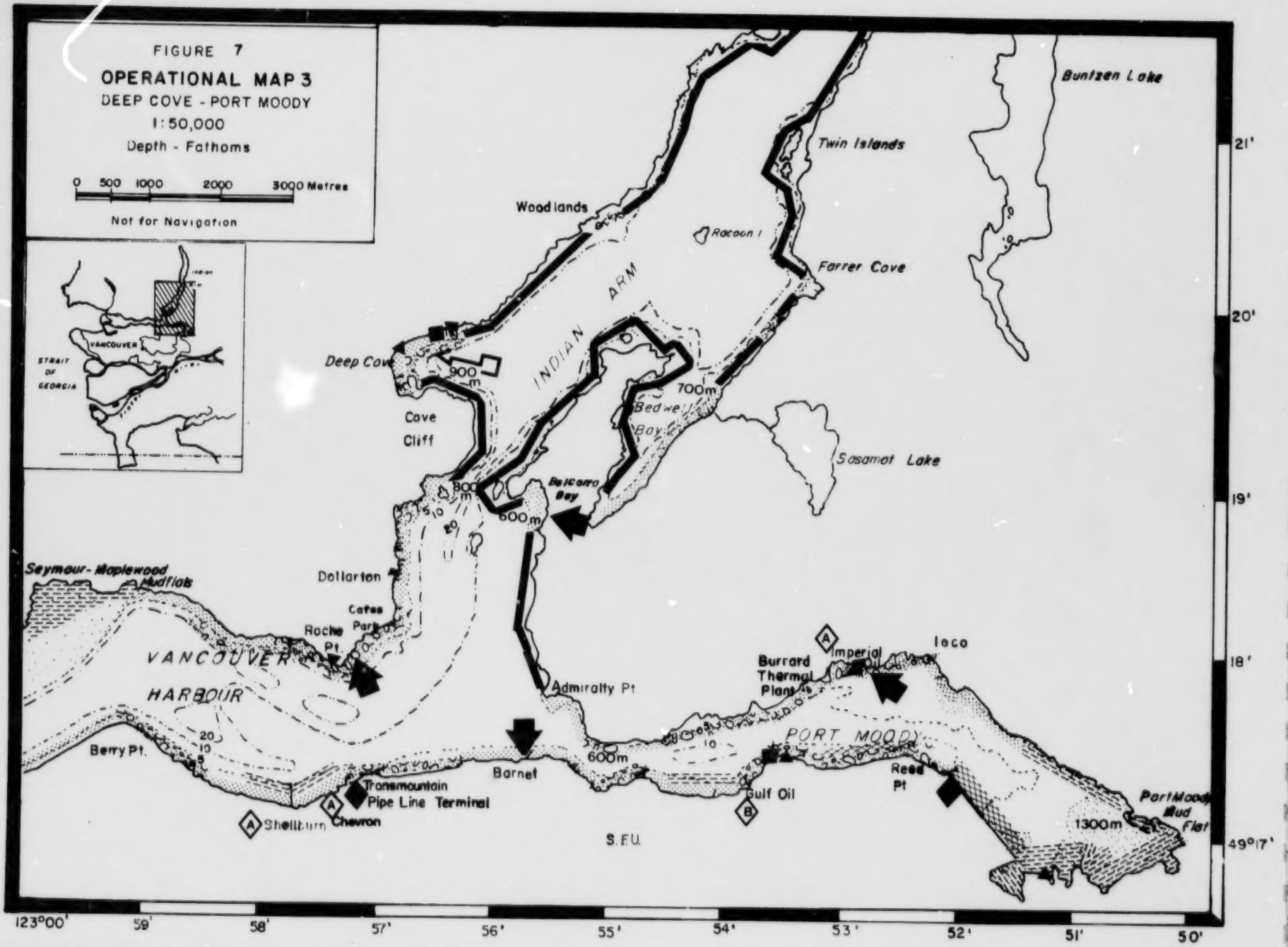


FIGURE 7
OPERATIONAL MAP 3
DEEP COVE - PORT MOODY
1:50,000
Depth - Fathoms
0 500 1000 2000 3000 Metres
Not for Navigation
VANCOUVER
STRAIT OF GEORGIA
Buntzen Lake
Twin Islands
Woodlands
Racoon I
Farrer Cove
INDIAN ARM
Deep Cove
900 m
700m
Bedwell Bay
Cove Cliff
Sasamat Lake
800 m
600m
Belcarra Bay
Seymour-Maplewood Mudflats
Dollarton
Cates Park
Roche Pt
VANCOUVER HARBOUR
Admiralty Pt
Burrard Thermal Plant
Imperial Oil
Ioco
PORT MOODY
Berry Pt.
Barnet
600m
Transmountain Pipe Line Terminal
Chevron
Shellburn
Gulf Oil
Reed Pt
Port Moody Mud Flat
1300m
S.F.U.
123°00'
59'
58'
57'
56'
55'
54'
53'
52'
51'
50'
21'
20'
19'
18'
49°17'

Legend

Shoreline Classification

Bedrock cliff

Rock platform

Mixed sediment

Sand

Tidal flats

Sequence of rocky headlands and pocket beaches

Man-made

Access

Docking facility

Launch ramp

Staging area

Float plane landing

Helicopter pad

Marine Access

Resource Material

Hydro charts 3483, 3435, 3484

Topo maps 92 G/7

Video tape 6 & 7

Countermeasures

Oil spill package

Boom deployment metres (m)

Sacrificial beach

Oil collection point

Oil burning site

Oil disposal site

Operational Map 3 Deep Cove - Port Moody

Spill Response

Open water containment and recovery of spilled oil is definitely feasible in this area though tidal currents and winds could be serious constraints. Spill clean-up in open water should be directed at limiting the passage of oil toward the Seymour-Maplewood mudflats and the Port Moody mudflats.

In the event that slicks threaten shorelines, efforts to divert them onto sacrificial beaches should be attempted. Though this is normal procedure, several considerations should be reiterated. The concept of sacrificial beaches is directed at improving the potential for oil recovery, instead of permitting oil to come ashore on shorelines which may have greater ecological value or are composed of materials where clean-up effectiveness is low.

Other areas sensitive to oil spills due to biological productivity, recreational value and aesthetics are Deep Cove, Bedwell Bay and Belcarra Bay.

Protection

Seymour-Maplewoods Mud Flats and Port Moody Mud Flats are very difficult areas to protect owing to their great size. The Seymour-Maplewood Mud Flats is the last major marsh and mud flat area in Burrard Inlet and is a common estuary of the Seymour River, McCartney and Taylor Creeks and other smaller unnamed systems. It comprises some 112 hectares. Diversion and containment booms as

well as skimmers, slick lickers etc., stationed just off the mud flats would be essential in keeping incoming oil away from this area.

Deep Cove and Bedwell Bay can both be protected by booms placed across the entrance. If oil reaches Bedwell Bay shoreline clean-up should be concentrated at the high tide area. An eel grass bed raises the ecological sensitivity of this area. Smaller islands such as the Twin Islands and Racoon Island can be protected by diversion booms. These may be placed strategically to divert oil into areas easier to clean.

Belcarra Bay is part of a marine park containing extensive shellfish beds, crab, shrimp and other organisms sensitive to both surface oil and hydrocarbon contamination in the water column. It can be protected by diversion booms or by exclusion booms stationed across the bay entrance.

The smaller open areas such as Woodlands and Farrer Cove can be protected by exclusion booms. These pocket beaches can be prepared by laying out sorbent pads at the high tide line.

If conditions are calm, and tidal currents slack, booms can be strung across the narrowest point of Indian Arm between Turtle Head and Hamber Island (150 meters off Belcarra Park) and between Hamber Island and the opposite foreshore below Cove Cliff (1200 metres approx.).

Clean-up

The principal shoreline types are all found in the Deep Cove - Port Moody operational area. The most sensitive ecologically are the Seymour Maplewoods mud flats and the Port Moody mud flats, which would be high priority

sites should containment fail. Low pressure flushing with copious amounts of water would be the optimal strategy for cleaning these flats. Once flushed, oil must be collected and removed from receiving waters. Shallow draft vessels and floating platforms would be required to support skimming operations. Only at or near the high tide line could men and equipment be permitted to remove stranded oil. Should macrophytic vegetation in the Seymour - Maplewood mud flats be extensively oiled, several options are available. The first would be to allow natural cleaning to take place. The second would be to apply low pressure, low temperature flushing toe the contaminated vegetation, thus helping to lift off the oil which could then be collected and removed. The third alternative would be manual cutting, the fourth burning. Any decision should be made in consultation with an environmental biologist.

Deep Cove is an extensively used recreational area with a marina. It also offers some refuge for wildlife, mainly waterfowl. It should be cleaned as soon as is possible if booming has failed. The use of the marina is heaviest in the summer months and boat traffic could interfere with clean-up operations unless restricted. Property owners should be approached for shoreline access, kept informed and assured that damage will be corrected.

Deep Cove's shoreline consists of sand and mixed sediment, with a few silty areas. Low pressure flushing would be one method of cleaning the shoreline. If contamination were heavy, then removal of sediments may be required. The sediment must be cleaned and replaced, or restored using similar sediments. The residential population of the area may want to be involved in clean-up operations, through deployment of absorbant pads, peat moss, etc.. Oil controlled on the water surface by containment booms can be removed with skimmers.

Bedwell Bay is a quiescent area, with shorelines composed of sand and mixed sediment on the east side and rock on the west side. At the foot of the bay there is extensive eel-grass bed which must be protected.

Cates Park in North Vancouver is used year round, most heavily in summer. The shoreline consists of mixed sediment with sand pocket beaches. Low pressure flushing should clean most of the contamination if oiled, while removal of sediments using front end loaders and scrapers would be required with heavier contamination.

Shorelines in Indian Arm are mainly steep bedrock cliffs. Access is poor due to impassable headlands and steep intertidal zones. Shoreline clean-up would be labour intensive and require boats. As this is a calm area, exposed rocky shorelines otherwise suited to natural cleaning by wave action may have to be cleaned using high temperature hydroblasting, steam cleaning, and considerable manual labor.

The remainder of the Port Moody and Burnaby waterfront consists of man-made structures, sand or mixed sediment. Docks, piers, break-waters, buoys etc. can be cleaned using hot water flushing and steam cleaning.

Extensive log booms in the Barnet area will trap oil if contaminated. This can normally be removed during de-barking but care should be taken to collect and recover oil and debris.

Access

Land and marine access to this entire area is variable, with the exception of Indian Arm which is accessible only by boat. Roads lead throughout the area from Deep Cove in the west and Farrer Cove in the east, but

access to the waterline is frequently poor. As a consequence, much of the clean-up would have to be coordinated from the water. There are boat ramps in Cates Park, Deep Cove, Bedwell Bay, Port Moody, and the Barnet area. There are also extensive private and public docking facilities in Deep Cove, Bedwell Bay, Port Moody and along the Burnaby waterfront.

Sea planes can be landed near Deep Cove and helicopters can land in many places. Care must be taken to avoid high voltage wires and cables across Indian Arm and Moody Arm. There are road maps, topographical maps, and hydrographic charts available for this area.

Biological Resources

Seymour Maplewood is the largest marsh remnant in Burrard Inlet and is heavily used by waterbirds which make up some 84% of the species present. Waterfowl and diving ducks in particular utilize the mud flats. Dabbling ducks use the marsh areas on high tide and the mud flat periphery on low tide. This area is particularly vulnerable in the winter when ducks use is highest. It is estimated that about 10,800 wintering birds depend on the Seymour-Maplewood Estuary, with 50% specifically dependent on the mud flats.

This being the largest estuary system within the inlet, it takes on a special significance for the fishery resource. Important species such as juvenile chum, chinook and coho salmon are known to feed in the estuary. Heaviest use is from April through August in nearshore areas.

The estuary also supports a large and diverse population of macro-invertebrates dominated by crustaceans, annelids and soft-shelled clams found in muddy sand intertidal areas. Mussels, barnacles and shore crabs utilize gravel and sand areas.

Log storage and resultant debris are currently the most environmentally damaging activities affecting the Seymour-Maplewood foreshore area. There are potential hazards from accidental spills from nearby chemical based industries.

The mud flats of the Port Moody area at the head of the inlet provides a similar though less productive habitat than the Maplewood Estuary. Invertebrates in Port Moody include barnacles, mussels, horse clams, little-neck clams, cockles, Pacific oyster, shrimp, geoduck, and edible shore crabs. Port Moody Arm nearshore areas provide rearing habitat for juvenile chum and pink salmon from April through August. The area provides habitat for hundreds of dabbling and diving ducks, divers, and gulls, primarily from October to April. Small numbers of gulls and Canada geese nest in the area. Harbour seals are frequently seen.

Cates Park, Deep Cove, and Bedwell Bay all have wintering populations of waterbirds, including ducks, cormorants, grebes, mergansers and herons. Small numbers of marbled murrelets occur in the open waters of this area throughout the year. Cates Park and Belcarra Bay, both have major clam beds, and there is a large concentration of crabs in the deep water from Twin Islands south, and Roche Point east into Port Moody. All shallow water areas along the shore provide salmonid fry rearing habitat.

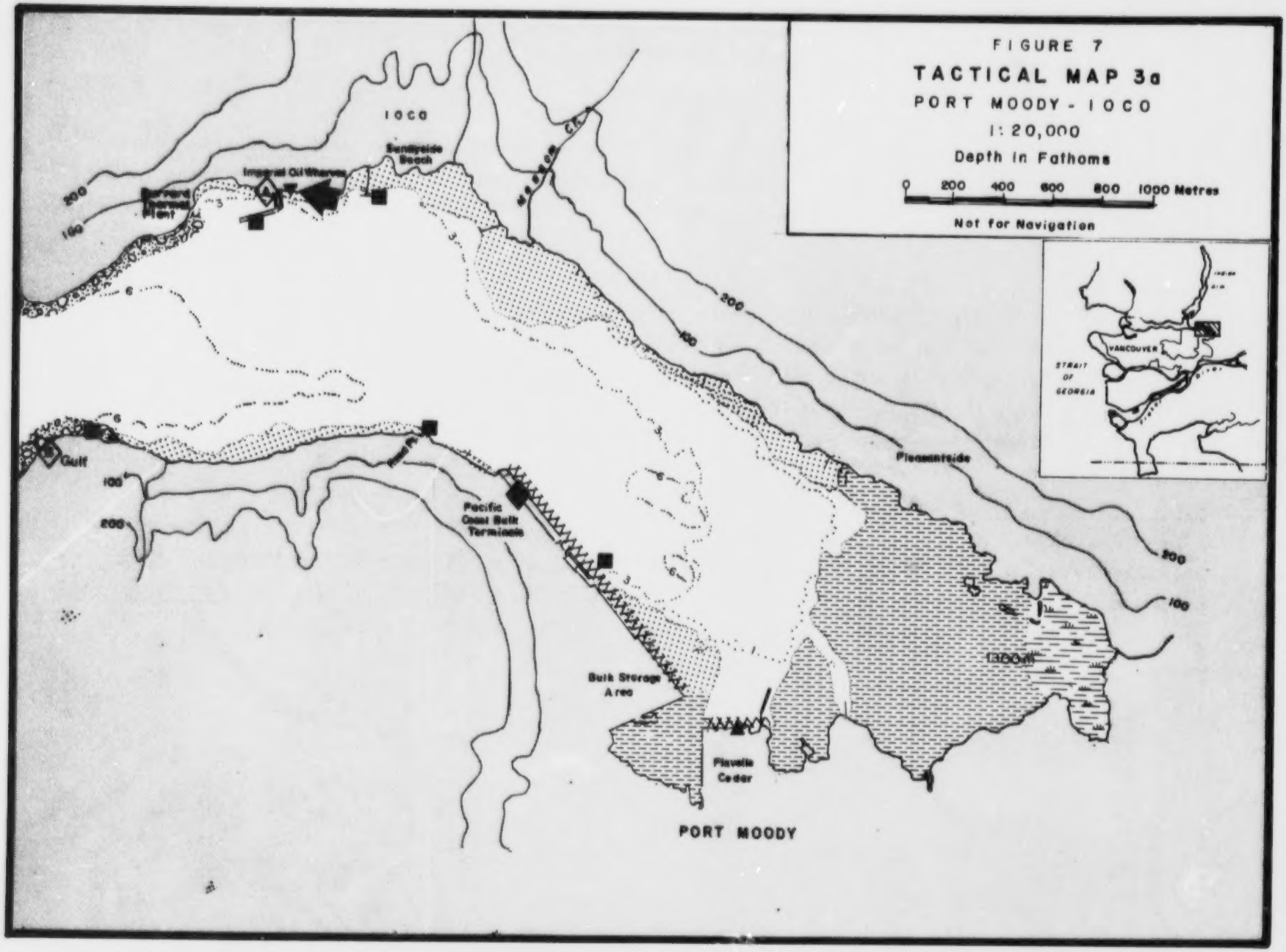
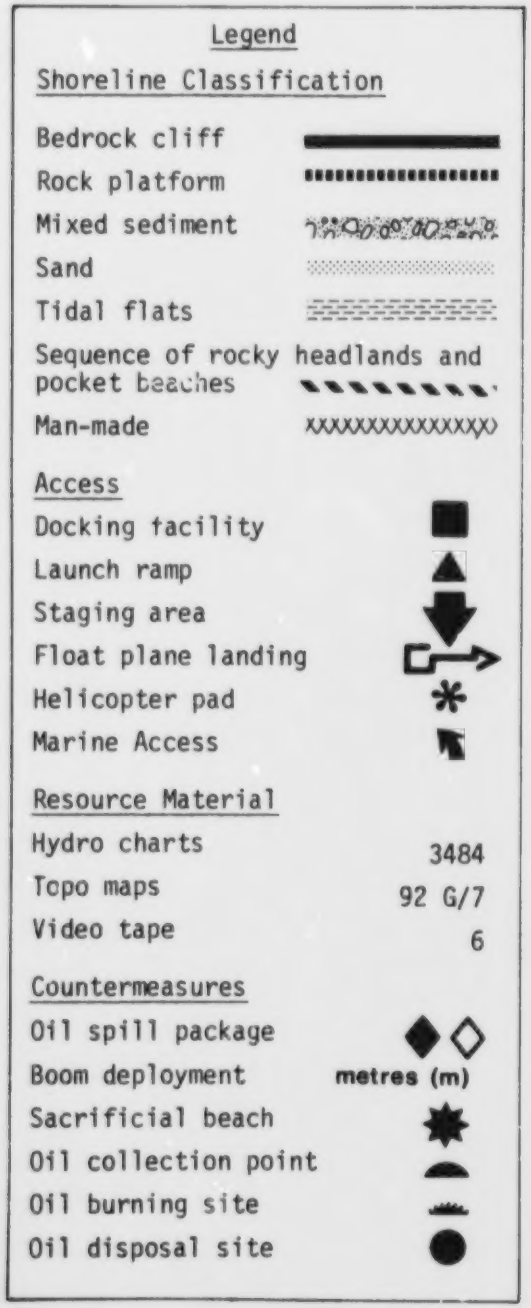


FIGURE 7
TACTICAL MAP 3a
PORT MOODY - IOCO
1: 20,000
Depth in Fathoms
0 200 400 600 800 1000 Metres
Not for Navigation
IOCO
Sandpoint Beach
Imperial Oil Wharves
Gulf
Pacific Coast Bulk Terminals
Bulk Storage Area
Fibreville Cedar
Pleasantside
1300ft
PORT MOODY
VANCOUVER
STRAIT OF GEORGIA



Tactical Map 3A Port Moody - Ioco

Protection

Because of the extensive dimensions of the intertidal flats in Port Moody, where clean-up would be difficult, the oil spill response strategy should take the following form. First, the priority area to deal with the oil would be the open waters of the port. This would seem to be the best protection strategy. It also has a reasonable chance of success, relative to other areas. This is because it is comparatively sheltered, allowing open water boom deployment, containment, and skimming operations to take place with less chance of interruption due to high wind and waves.

Isolating Port Moody from oil originating to the west, using exclusion or diversion booms would be a feasible move if tidal currents in the narrows opposite Burns Point were less than one or two knots.

The second part of the countermeasures strategy would be to divert any shore-bound oil toward beaches where clean-up could be effective. Sunnyside Beach on the north side and smaller sandy areas immediately to the east, plus some small beaches west of Read Point are possible candidates for sacrificial beaches.

Clean-up

Most of the Port Moody shoreline is tidal flat, and it is relatively silty. This explains the emphasis on sacrificial beaches. At Sunnyside Beach and other

smaller beaches which could become oiled, standard beach cleaning methods would be used. The beaches would be prepared by the extensive application of sorbent pads and/or the construction of a ditch-dyke system at the mid-tide level. Polyethelene sheeting applied to the ditch element in the system could limit oil penetration into sediments and facilitate pumping of recovered oil. Recovery of oil stranded elsewhere on beaches would be accomplished with varying combinations of motor graders, elevating scrapers, front-end loaders, bulldozers, backhoes, draglines and clamshells.

In a large oil spill, some oil would undoubtedly reach the mud flats. The third element in the Port Moody countermeasures strategy would be to deal with this. Low pressure flushing would be the method used to remove oil stranded at the low or mid tide levels. Oil stranded at the high tide line, where ecological sensitivities may be low, might be removed by a combination of loaders and other suitable equipment, plus manual labour. If clean-up activity of this sort is restricted to the high tide line, additional environmental damage could be kept to a minimum. Clean-up operations in the area of mud flats should be conducted with the advice of responsible environmental officials.

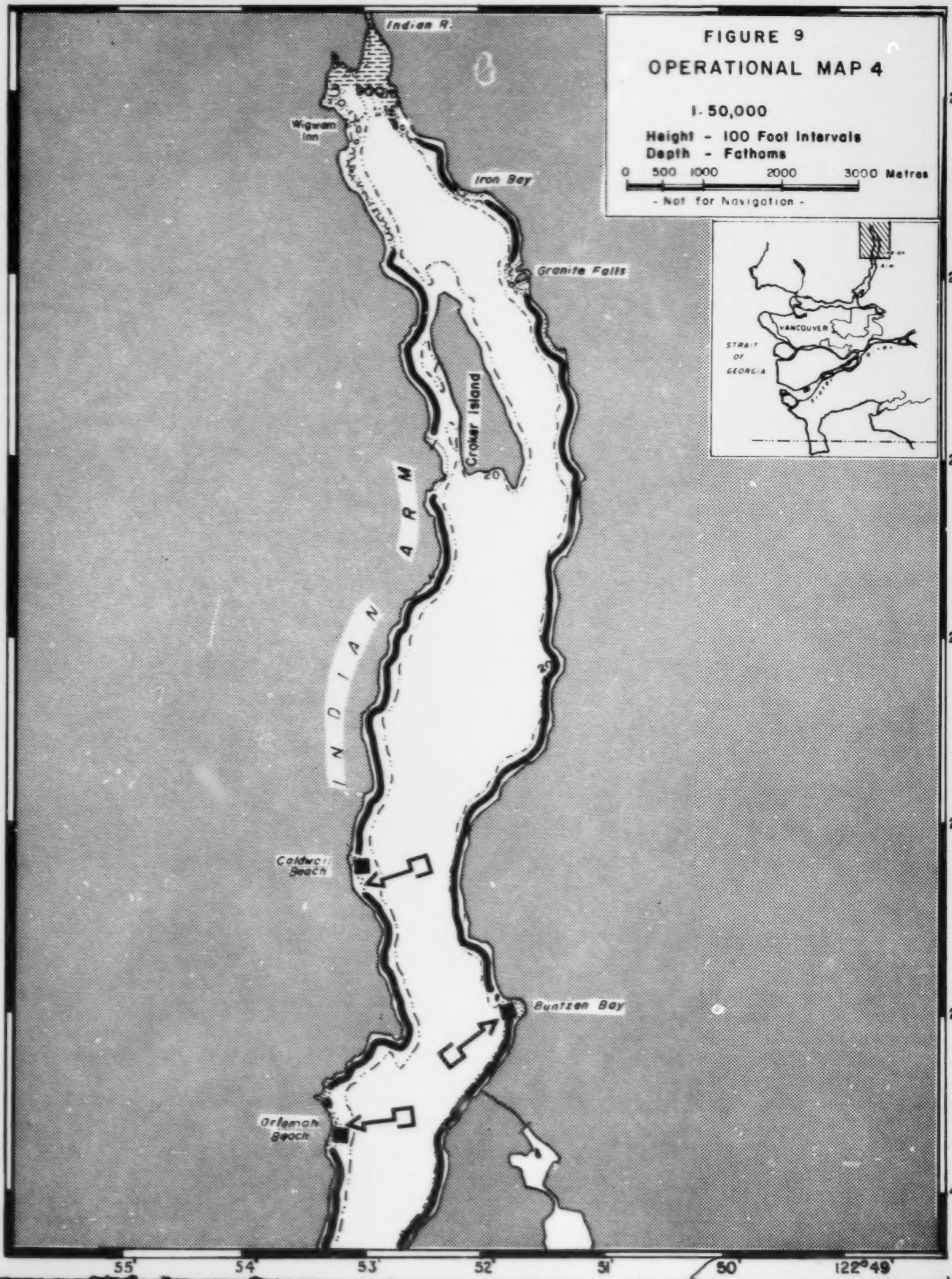


FIGURE 9
OPERATIONAL MAP 4
1:50,000
Height - 100 Foot Intervals
Depth - Fathoms
0 500 1000 2000 3000 Metres
- Not for Navigation -
Indian R.
Wigwam Inn
Iron Bay
Granite Falls
Croker Island
INDIAN ARM
Caldwell Beach
Buntzen Bay
Orlemah Beach
VANCOUVER
STRAIT OF GEORGIA
28'
27'
26'
25'
24'
23'
49°22
55'
54'
53'
52'
51'
50'
122°49'

Legend

Shoreline Classification

Bedrock cliff

Rock platform

Mixed sediment

Sand

Tidal flats

Sequence of rocky headlands and pocket beaches

Man-made

Access

Docking facility

Launch ramp

Staging area

Float plane landing

Helicopter pad

Marine Access

Resource Material

Hydro charts 3435

Topo maps 92 G/7

Video tape 7

Countermeasures

Oil spill package

Boom deployment metres (m)

Sacrificial beach

Oil collection point

Oil burning site

Oil disposal site

Operational Map 4 Indian Arm

Spill Response

The chances of an oil spill entering upper Indian Arm that does not originate within the Arm is unlikely. Response should concentrate on limiting the oil escaping from the source and localizing the spill with containment booms. If not possible, then all efforts must concentrate on protection of the Indian River Estuary. This is sensitive habitat for numerous fish, bird and mammal species. There is also a log storage operation to the east of the estuary. Most of Indian Arm is inaccessible due to bedrock cliffs. The only exception to this is a small number of pocket beaches on both sides of the arm, the Indian River Estuary and an open area near the Wigwam Inn on the west side at the head of the arm. This area was previously used for a gravel operation and is the logical point for a staging or focal area. Without exception all beaches are occupied by summer and/or full-time residents and are accessible by small boats. These beaches can be used as staging areas for clean-up equipment and may have to be used as sacrificial beaches as well. Because of the quiet, low energy nature of the Indian Arm, oil would accumulate and persist on the rock shorelines. It would be difficult to clean due to their steepness and the fact that all operations would have to be conducted by boat. Therefore, it would be advantageous to divert oil to beaches where fine grained sediments could either be cleaned or removed and replaced with similar material.

Protection

The main protection strategy should be to recover spilled oil in the open waters of Indian Arm. It is a relatively sheltered body of water making open water countermeasures feasible, except during the infrequent occurrence of "Squamish" or northwesterly winds.

The Indian River Estuary is the most sensitive area in Indian Arm. Exclusion booms should be used to protect this important estuarine marsh. During freshet, the Indian River freshwater will help prevent contaminants from contacting the river banks. Because of the nature of this area it may be possible to use absorbants on the edge of the more stable banks, using boats as work platforms (this would work best at high tide). If time and equipment allow, the pocket beaches in upper Indian Arm should also be protected and/or cleaned. Coldwell Beach, Buntzen Bay and Orlahama Beach are ideally suited as sacrificial beaches due to location and sediment type. Crocker Island can be protected by strategically placed diversion booms.

Clean-up

Virtually all of the Indian Arm shorelines are bedrock cliff (Figure 9). These can be cleaned using high temperature hydroblasting or steam cleaning, particularly in areas where oil coating is thick and could lead to recontamination.

Small pocket beaches are sites where diverted oil can be cleaned. These beaches should be prepared by applying absorbent pads prior to oiling. Much of the clean-up will have to be manual, owing to the difficulty of getting equipment to these isolated sites.

Should the Indian River estuary be oiled, the least damaging cleaning method would be low pressure flushing of the marshes and coarse sediments. Only at the high tide line should men and equipment be used to pick up oil off the substrates.

Access

Indian Arm is entirely different in character from Burrard Inlet. The arm is 20 km long, 1.5 km wide, and up to 220 meters in depth, has many shoreline slopes in excess of 50% and few less than 15%. It is enclosed on both sides by 1500 m mountains. During spring and summer, snow melt reduces salinity in surface waters. There is no road access beyond Woodlands on the west side and Bedwell Bay on the east side. From there, vertical cliff walls impede boat landings and foot access. Orlohama Beach is the site of the prominent dock and floats of the Children's Jubilee Summer Camp. There are several private floats in Buntzen Bay and Coldwell Beach and to the north of Best Point a number of private jetties and floats. Granite Falls houses ruins of a float, and small boats can probably land here. Iron Bay, on the north east
end, has a large logging camp with numerous buildings. The bay and the coast northward to the mouth of the Indian River are used as booming grounds and log dumps. The Wigwam Inn has a large float out in front of it. Access to Indian River Estuary is limited depending on tide. There is no docking area and foot traffic should be limited due to its sensitive nature. Sea planes can land anywhere. Care must be taken to avoid high voltage wires and cables across Indian Arm.

Biological Resources

The Indian River produces substantial numbers of chum, pink and coho salmon. The down-stream migration of juvenile pinks may occur in February, and the chum salmon migration occurs anytime from late March to

mid-April. Coho salmon juveniles move into Indian Arm by May having spent a year in the river. Considerable numbers of juvenile salmon remain in the nearshore of Indian Arm through spring and summer. At this stage they are vulnerable to oil spill.

During fall and winter, small flocks of birds (grebes, dabbling and diving ducks, alcids) occur on the waters of Indian Arm, concentrating in the estuary. Harbour seals are common.

The Indian River estuary, although small, has all the characteristics and sensitivities common to larger estuaries.

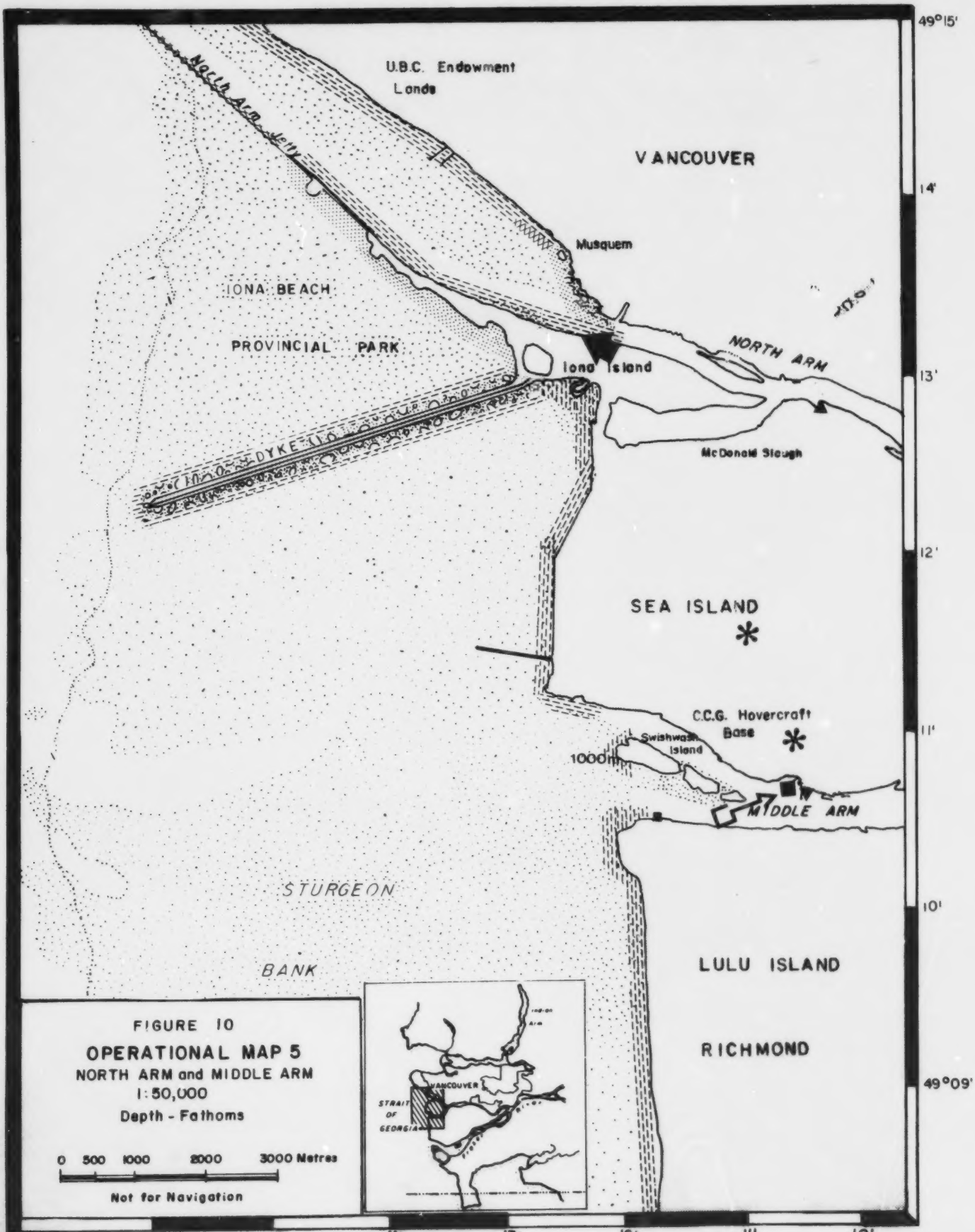


FIGURE 10

OPERATIONAL MAP 5

NORTH ARM and MIDDLE ARM

1:50,000

Depth - Fathoms

Legend

Shoreline Classification

Bedrock cliff

Rock platform

Mixed sediment

Sand

Tidal flats

Sequence of rocky headlands and pocket beaches

Man-made

Access

Docking facility

Launch ramp

Staging area

Float plane landing

Helicopter pad

Marine Access

Resource Material

Hydro charts	3480
Topo maps	92 G/3
Video tape	2 & 3

Countermeasures

Oil spill package

Boom deployment metres (m)

Sacrificial beach

Oil collection point

Oil burning site

Oil disposal site

Operational Map 5,6,7 Fraser River Estuary North Arm - Point Roberts

Spill Response

Compared to other areas covered in this operational map series, the Fraser River Delta and Estuary is much more important ecologically; its biological productivity, species diversity, and population abundance are significant everywhere. This means protection priorities are not obvious; instead, the spill response should be directed in areas where it will be most effective. Protection is of the utmost importance as all of the estuary forms productive biological habitat.

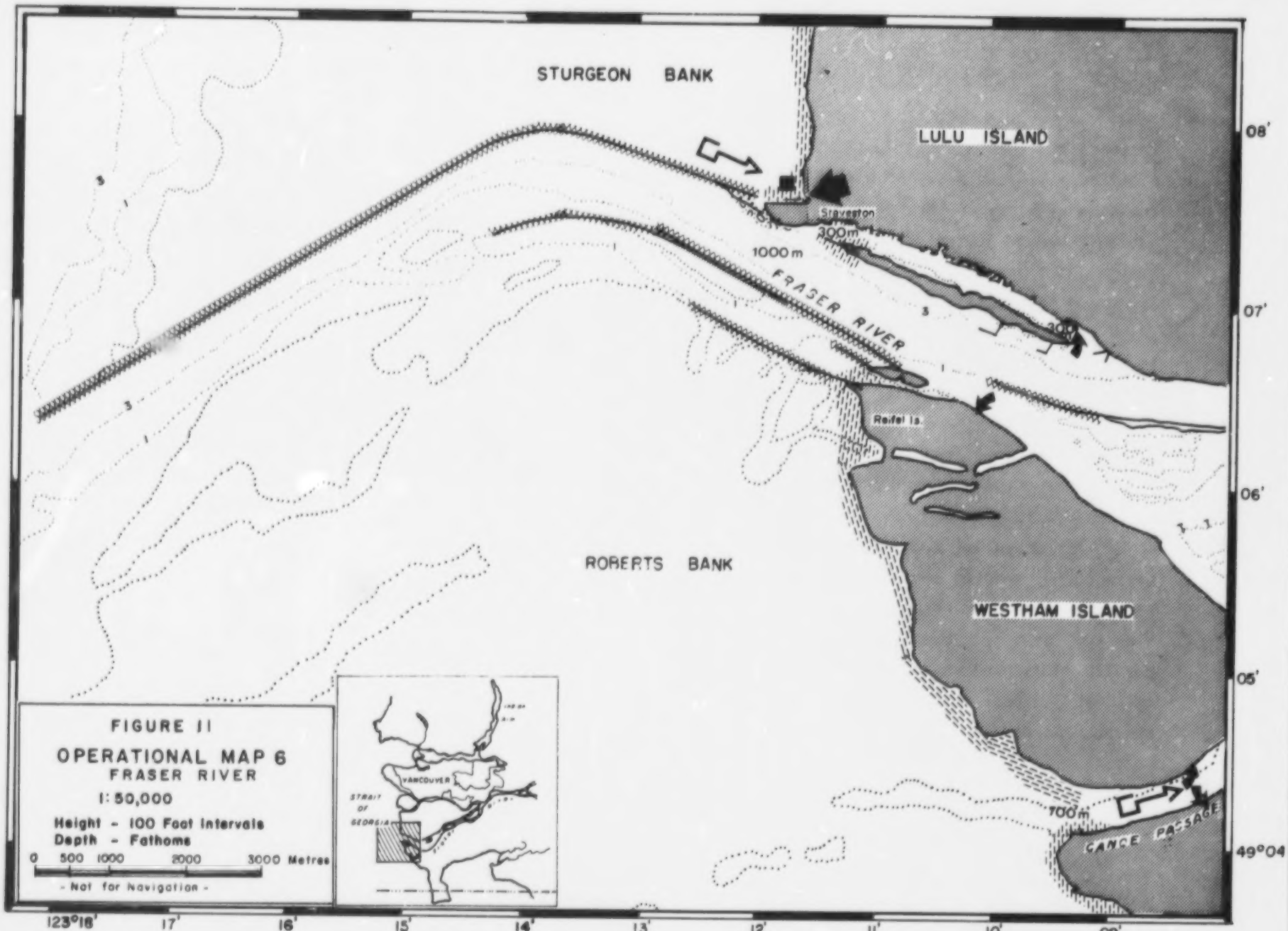
Two important forces would limit response operations in the Fraser Estuary. The first is the flow of the Fraser River. During much of the tidal cycle, currents are in excess of 0.5 knots. This means that where current occurs, i.e. in the main channel, side channels, and areas immediately adjacent, no effective containment is possible. Over the short-term this could be advantageous as current may be the best means of directing oil away from marshes into open water.

The second influence is exposure to the oceanographic and meteorological forces of the Strait of Georgia. Winds, waves, and currents separately or in combination for most of the year put limits on effective use of booms to protect the marshes from oil. The time when these forces would not interfere with containment operations is fairly short, even during the favourable weather of July and August.

Protection

With these limitations, and with tne assumption that oiling the marshes is the worst outcome of a spill, the main strategy in the Fraser Estuary should be to keep oil offshore. Offshore containment with deep-sea booms should be attempted immediately, coordinated with large skimming devices. Because of the frequent high winds and waves, serious consideration should be given to dispersant application of those slicks which are known from spill modelling to be destined for the marshes. In addition, slicks should be chemically dispersed only at an ecologically acceptable distance from the banks. A further argument in favour of considering dispersant application is that flow of the river plus winds and tidal currents have the potential to direct oil onto the shores of the Gulf Islands, or south to the United States. Dispersing offshore slicks might successfully limit this tendency. On the plus side, dispersant application employed strategically could reduce shoreline and marsh contamination with its attendant ecological implications. On the debit side, the effectiveness of dispersant application is questionable, and the ecological effects of spraying in open waters of the Strait of Georgia may be significant.

Priorizing areas for protection in the Fraser Estuary cannot be effectively done because of ubiquitous biological resources and high uniform sensitivities. Certain areas have special values which would likely warrant special attention. Conspicuous is the Reifel Island Bird Sanctuary, which attracts the public to view the large migratory and winter population of waterfowl and shorebirds, and a modest but expanding population of breeding ducks and geese. The area around the refuge should be protected by booms if immediately threatened by oil. Oil contamination here should be cleaned as a priority, assuming operations can be conducted effectively.


STURGEON BANK
LULU ISLAND
Steveston
300m
1000 m
FRASER RIVER
Reifel Is.
ROBERTS BANK
WESTHAM ISLAND
700m
CANOE PASSAGE
08'
07'
06'
05'
49°04
123°18'
17'
16'
15'
14'
13'
12'
11'
10'
09'
VANCOUVER
STRAIT OF GEORGIA
FIGURE 11
OPERATIONAL MAP 6
FRASER RIVER
1:50,000
Height - 100 Foot Intervals
Depth - Fathoms
0 500 1000 2000 3000 Metres
- Not for Navigation -

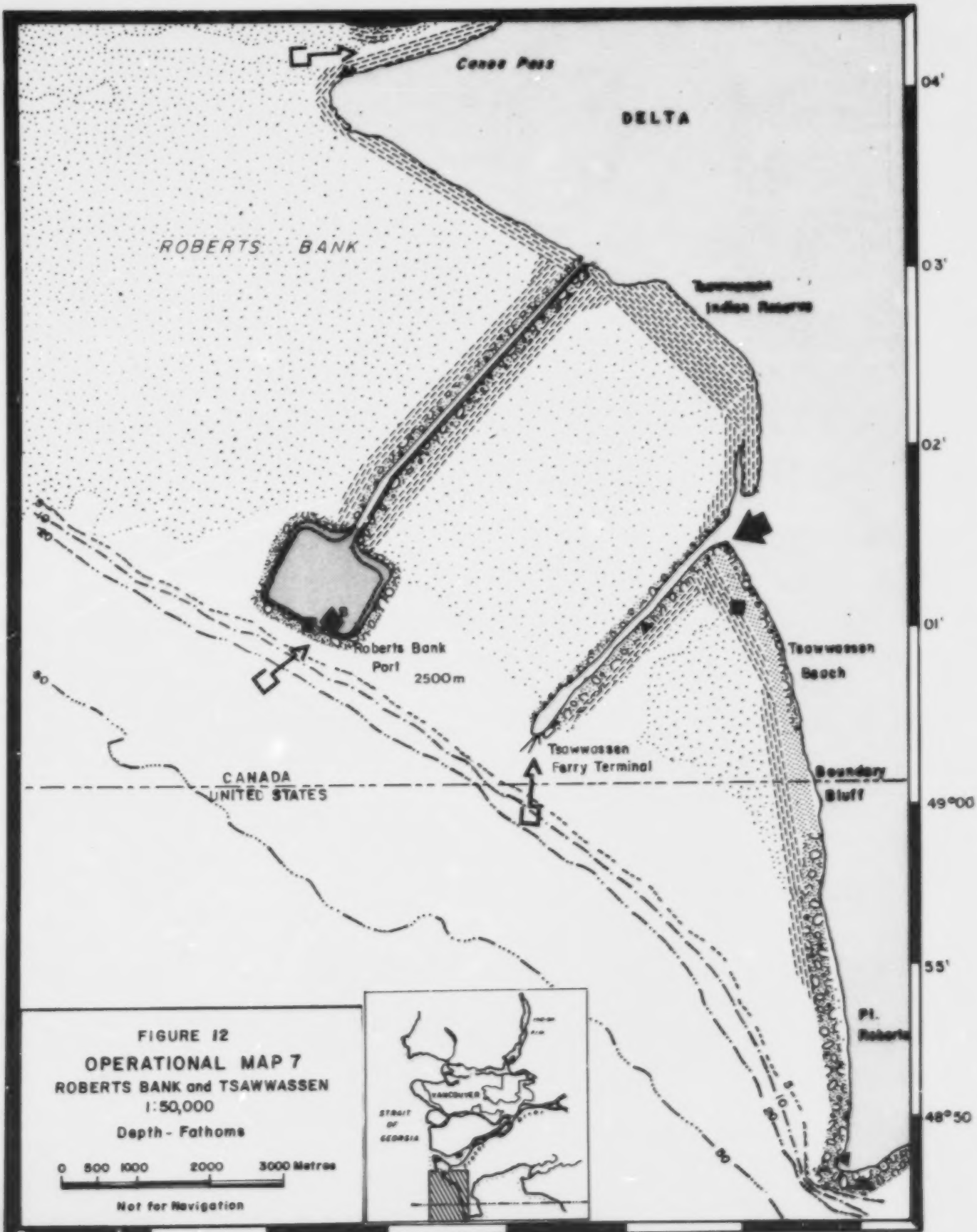
The main protection priority should be the marshes. As identified above, efforts should be directed at preventing offshore oil from reaching estuarine marshes and other nearby shorelines (e.g. Gulf Islands). This may require dispersants while in some cases containment booms may be more effective.

Clean-up

For the flats and marshes several strategy options should be considered. First, proportionally little oil will strand on the flats, except during ebb tide. Because it will be lifted off on the subsequent flood there is little argument to expend much effort here. At most, gentle flushing could direct the oil to where recovery/skimming operations were taking place. Most oil will strand in the vegetation at the high water line. For many reasons it cannot be left here, though clean-up operations frequently appear to accentuate the problem. Whatever strategy is employed, efforts should be directed to limit foot traffic in oiled areas. Pooled oil should be removed first. Small pumps and absorbents could recover considerable quantities at high water. This lessens the possibility of oil floating offshore and contaminating another area. If vegetation is standing, stalks should be cut and removed, starting in those areas where oiling is heaviest. This procedure will not work as well after October when Scirpus and Carex stands have fallen over and are decomposing. Should effectiveness be marginal in any area the On-Scene-Commander should be prepared to deploy countermeasure elsewhere. Even though shoreline clean-up in a marsh could be frustrating, dispersants should not be applied.

Access

Access to the foreshore area of the Fraser River Estuary is not particularily good either from the seaward or landward side. Most jetties are accessible by public or private road. These include North Arm Jetty,


Canoe Pass
DELTA
ROBERTS BANK
Tsawwassen Indian Reserve
Roberts Bank Port
2500m
Tsawwassen Beach
Tsawwassen Ferry Terminal
CANADA
UNITED STATES
Boundary Bluff
Pt. Roberts
04'
03'
02'
01'
49°00
55'
48°50
123°12
11'
10'
09'
08'
07'
06'
05'
VANCOUVER
STRAIT OF GEORGIA
FIGURE 12
OPERATIONAL MAP 7
ROBERTS BANK and TSAWWASSEN
1:50,000
Depth - Fathoms
0 500 1000 2000 3000 Metres
Not for Navigation

Iona Island Dyke, Steveston Jetty, Roberts Bank and Tsawwassen Jetty. Lulu Island and Sea Island have roads near or to marsh areas. In order to access marsh and foreshore areas, in most cases, foot travel is required. This is sometimes difficult as sediments are soft and unstable. The estuary can be reached at the mouth of the North Arm, Middle Arm, the main reach of the Fraser, and via Canoe Passage. Vehicular accessibility is also better here. Steveston, for example, at the mouth of the Fraser is an industrial area and totally accessible by sea and land. It is also a good staging area for boats, seaplanes, trucks, oil spill clean-up equipment and personnel. Docking, launching, fueling, and storage facilities, restaurants, motels, etc. are all available in Steveston.

The shores of Sea Island can be reached via Vancouver International Airport, and Canadian Coast Guard Hovercraft Base on the Middle Arm. Most of the coastline is inaccessible to all but very shallow draft boats and hovercrafts due to the nature of the marsh area, and the dewatering of the banks during low tides.

Tsawwassen Ferry Terminal is built to accommodate large B.C. ferries and caution must be exercised by boats navigating the area. Adjacent to the ferry terminal on the south-east side moorage facilities are available at the Tsawwassen Yacht Club. There is also a launching ramp and boat storage compound present. Westshore Terminals or Roberts Bank Coal Port acts both as a breakwater and deterent, or trap, depending on conditions in the area. The vessels using this facility are mostly bulk carriers but the port may be useful for docking barges deployed for oil spill clean-up or containment.

Marine waters at the Fraser River mouth or off Roberts Bank can be hazardous under certain conditions. Canoe Passage, south of Westham Island is navigable only by small craft. The Middle Arm can be accessed by

small and medium sized pleasure craft. Caution must be taken when navigating the main channel due to heavy traffic by deep sea vessels, tugs, barges, log booms, and gillnetters.

Detailed hydrographic charts, continually updated to record dredging operations on the Fraser, are available for both the foreshore and riverine areas from Public Works Canada.

Biological Resources

The biological resources of the Fraser River and Estuary are not only important from a Canadian perspective, they have international significance. Although ecological values encompass most groups of fish and wildlife, Pacific salmon is by far the most significant and economically important biological resource.

Five species of Pacific salmon as well as anadromous trout and char spawn in the Fraser River system. Adult passage through the estuary extends all year, but the main runs pass through during June to November. The duration of lower river migration, and thus the vulnerability of both stocks and the commercial fishery to a major oil spill, is variable dependent on temperature, discharge, tidal cycles, and individual run timing.

Downstream migration of juvenile salmon through the estuary starts in March and chinook fry are resident as late as August. Throughout this period the main channel, major side channels, and all marshes provide essential rearing habitat for juveniles. In addition, high concentrations of chum and chinook fry have

been recorded near Woodward Island and on Sturgeon and Roberts Banks. Fry and smolts of other salmonids pass through the lower river and estuary on a much faster timetable. It is during the fry stage that salmonids are most vulnerable to the effects of an oilspill, although smolts may also be vulnerable if foraging in nearshore waters.

Among the other fish occurring in the estuary, sturgeon and flatfish represent significant resources. Flatfish occur in shallow water and are vulnerable to a spill. Eulachon pass through the estuary in April and May in transit to spawning grounds, and would be threatened by spills during river entry.

Shellfish are an important resource in the estuary. Crabs are abundant and harvested on Roberts Bank. Shrimp are taken offshore and bivalves are abundant on the banks. The inconspicuous planktonic juvenile stages of these crustaceans and sessile organisms such as bivalves are most vulnerable to oil contamination. Similarily vulnerable to oil are estuarine invertebrates that provide food for salmonids and other fish species.

Second in importance to the salmon resource of the Fraser Estuary are waterfowl. Tens of thousands of birds utilize the estuary as a migratory stopover and wintering site. Most of these are dabbling ducks, but there are important populations of snow geese, trumpeter, and whistling swans. Diving ducks and divers of various species are also common in deeper waters.

Like waterfowl, large numbers of shorebirds use the estuary, particularly the mudflats, as a migratory stop or wintering area. Other wildlife include a population of several hundred harbour seals which congregate in

several locations on the banks during summer, dispersing more widely during other periods. Pupping takes place during summer, and at this phase seals would be most threatened by an oilspill. Sealions congregate at haul-outs along the Steveston North Jetty in spring.

This summarizes briefly the most conspicuous of the biological resources of the Fraser River and Estuary. The value of eelgrass beds located on Roberts Bank, extensive Carex and Scirpus beds, and numerous invertebrate prey species should not be ignored. Damage to this ecosystem could have a significant effect on the distribution, abundance and survival of important fish or wildlife resources should an oilspill occur.

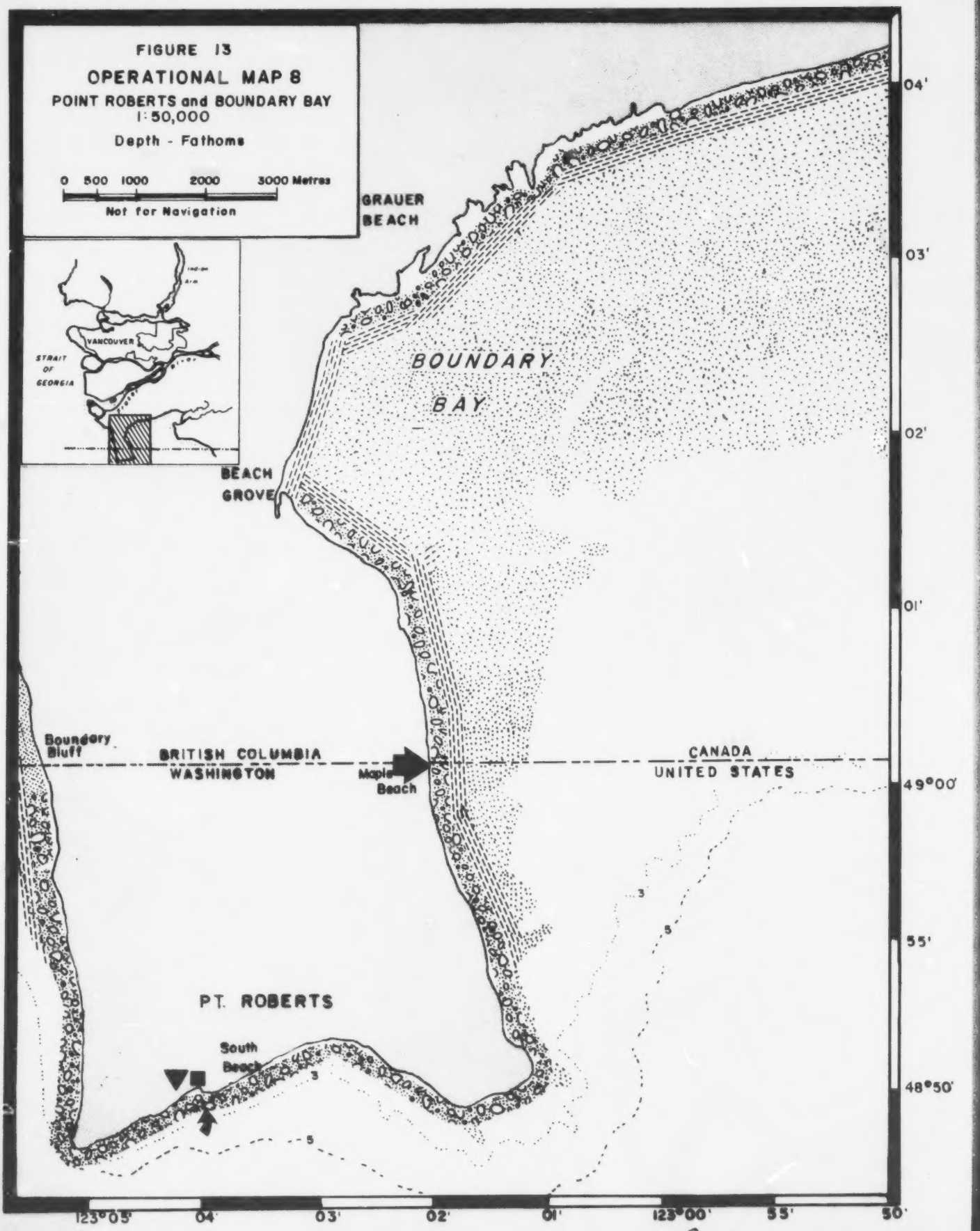


FIGURE 13
OPERATIONAL MAP 8
POINT ROBERTS and BOUNDARY BAY
1:50,000
Depth - Fathoms
0 500 1000 2000 3000 Metres
Not for Navigation
VANCOUVER
STRAIT OF GEORGIA
GRAUER BEACH
BOUNDARY BAY
BEACH GROVE
Boundary Bluff
BRITISH COLUMBIA
WASHINGTON
Maple Beach
CANADA
UNITED STATES
PT. ROBERTS
South Beach
04'
03'
02'
01'
49°00'
55'
48°50'
123°05'
04'
03'
02'
01'
123°00'
55'
50'

Legend

Shoreline Classification

Bedrock cliff

Rock platform

Mixed sediment

Sand

Tidal flats

Sequence of rocky headlands and pocket beaches

Man-made

Access

Docking facility

Launch ramp

Staging area

Float plane landing

Helicopter pad

Marine Access

Resource Material

Hydro charts 3450

Topo maps 92 G/2 & 92 G/3

Video tape 1

Countermeasures

Oil spill package

Boom deployment metres (m)

Sacrificial beach

Oil collection point

Oil burning site

Oil disposal site

Operational Map 8 - Point Roberts and Boundary Bay

Spill Response

A spill in the Point Roberts-Boundary Bay area would have the additional element of an international (i.e. Canada-U.S.A.) response. At Point Roberts, exposure would make containment very difficult, particularly on the west side. The combination of tides, currents, and winds leave little opportunity to deploy booms and large skimmers, except off the east side of Points Roberts and the deeper waters of Boundary Bay. The frequent turbulence of these waters will tend to disperse oil naturally, but with a large spill shorelines would become oiled. The cobble shorelines of Point Roberts would be a challenge to clean, but their ecological sensitivity appears considerably less than the sand/mud flats of Boundary Bay.

Protection

Open water containment and recovery (in United States) is the first line of protection for Point Roberts and Boundary Bay. Most of these waters are exposed, however, and thus frequently characterized by wind and wave conditions beyond the capability of most containment and recovery equipment.

Boundary Bay would be the main protection priority of open water countermeasures. Specifically, this would include the eastern shoreline of Point Roberts and extend eastward to the boundary of Operational Map 8 (Figure 15). No part of this area is apparently more sensitive than others, all areas are equally important.

On the south shore of Point Roberts the inlet into the boat basin would be a priority site for booming, though prioritization in the United States would be made by appropriate responsible U.S. decision-makers.

Clean-up

Shorelines in this operational map area are largely composed of two types: mixed (fairly coarse) sediments along most of the Point Roberts shoreline, and tidal flats in Boundary Bay. The rather coarse Point Roberts sediments create difficult clean-up conditions should oiling be heavy. Low pressure flushing can be successful if the oil lifted off is quickly recovered, probably manually or with the limited involvement of equipment and loss of sediments. The on-site advice of geomorphologists and ecologists would be an important component of countermeasures here.

In Boundary Bay, the high ecological sensitivity would necessitate that any oil clean-up be undertaken with appropriate care and under the supervision of an expert. There would be several alternatives. Floating oil would be boomed and pumped off by skimmers. Stranded oil would only be picked up if deposited at the high tide line, where people and equipment could operate without undue damage to the flats. In parts of Boundary Bay, particularly west of 96th Street, the old logs and stumps would make this strategy almost impossible. Where pick up of stranded oil is not environmentally acceptable or physically practical, low pressure flushing at high water could direct oil towards recovery equipment. Lastly, it should be recognized that in certain areas, leaving the oil to disperse or degrade naturally could be the best environmental solution.

Access

Access to the shoreline in most parts of this area is good, but deceiving. In practice, access around Boundary Bay is excellent up to and along the dyke. Beyond the dyke toward the foreshore, debris in the form of logs and stumps, and soft substrates where debris is absent, put severe constraints on movement of men and equipment. In some areas sandy sediments will support graders, dozers, and front-end loaders if it were environmentally acceptable to use such equipment.

As a consequence, much of the clean-up in this area might best be accomplished using a fleet of shallow draft vessels. This would limit clean-up activities to flood tide and high water stages, at least if water based. Requirements for aircraft support would probably be minimal, but it is an asset that Boundary Bay airport is immediately adjacent. Float planes can provide support during high water, and helicopter access is excellent.

The bluffs at the southeast corner of Points Roberts preclude access to the underlying shoreline. However, in this specific location men and equipment can move at all tide stages but high water. Access is available from the west and the north.

Biological Resources

Boundary Bay is an area of high ecological productivity. At the boundary end it is shallow, and at the north end there is an extensive sand and mud flat (Figure 15). It can be characterized by its high numbers of shorebirds and waterfowl, dense shellfish populations, eelgrass beds, and abundance of fish habitat.

The greatest concentrations of waterfowl and shorebirds in the Vancouver area occur in Boundary Bay. Most of these are dabblers (mallard, teal, pintail, wigeon), which use the Bay September through May. Peak numbers occur in November. The numbers of diving ducks are much smaller, but they do occur year round with a peak in September. Pacific brant occur briefly in March-April; this is a species of considerable conservation interest. The majority of these birds, the dabbling ducks, are found over the flats within close proximity to the water's edge. With the exception of a short period in June, shorebirds occur year round with maximum numbers July to September, when vast flocks (estimated up to 100,000 per tide cycle) pass through on migration. Though they rarely swim, shorebirds concentrate near the waters' edge where they could easily become oiled.

Among the other common birds using Boundary Bay gulls are the most conspicuous. During the day various flocks are distributed along the waterline, plus some feeding offshore, but the most important concentration is at night when an estimated ten thousand plus roost on the deeper waters of the Bay.

Loons, grebes, cormorants, and herons are fish-eating groups which are relatively common at all times of the year. The first three are especially vulnerable to spills. Bald eagles, harriers, falcons, snowy and short-eared owls, and various soaring hawks are raptors which frequently use the flats. They would not likely come in contact with oil, but a major spill and countermeasures operations might temporarily reduce this habitat.

In Boundary Bay and Mud Bay, out of the direct influence of the Fraser River, the invertebrate faunas are more diverse, predominated by a wide range of bivalve molluscs. Boundary Bay supported the single most

productive oyster bed in British Columbia prior to its closure. It supports native, Pacific and Atlantic oyster species. Other bivalves include butter clams, little neck clams, mussels, cockles and mud clams which are apparently being harvested recreationally, despite the closure. A commercial finfish fishery currently operates in Boundary Bay, but coliform bacterial pollution has closed the shellfish fishery.

Boundary Bay provides spawning habitat for south coastal herring populations where eelgrass beds occur. As well, the Serpentine and Nicomekl Rivers contain populations of coho salmon, steelhead, and cutthroat trout, juveniles of which may reside in the bay or use it as a migratory route to offshore waters. Recreational fishing occurs at the mouths of both rivers.

In summary, Boundary Bay is an extremely productive area.

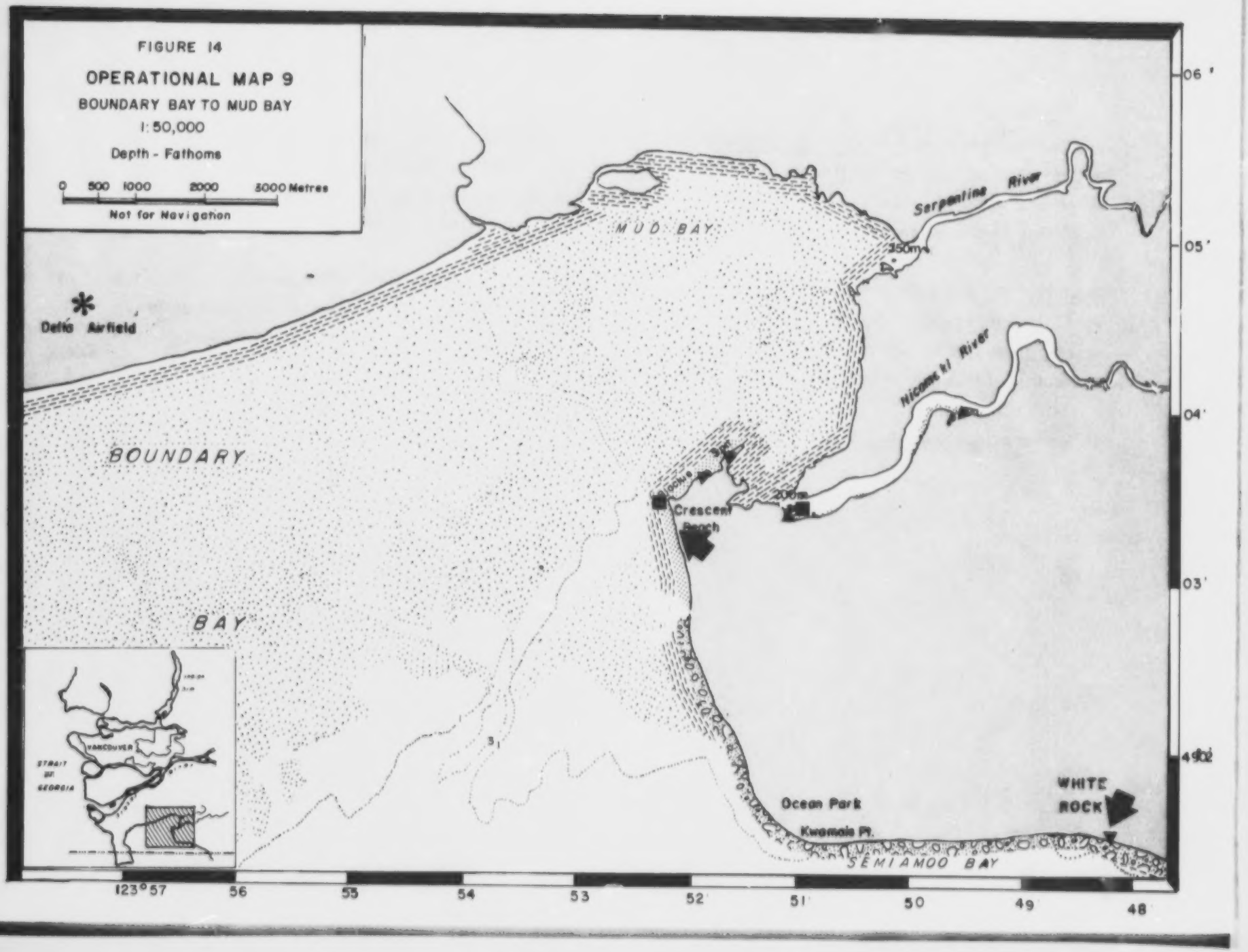


FIGURE 14
OPERATIONAL MAP 9
BOUNDARY BAY TO MUD BAY
1:50,000
Depth - Fathoms
0 500 1000 2000 3000 Metres
Not for Navigation
MUD BAY
Serpentine River
350m
Nicomekl River
Delta Airfield
BOUNDARY
BAY
Crescent Beach
200m
Ocean Park
Kwomais Pt.
WHITE ROCK
SEMIAMOO BAY
VANCOUVER
STRAIT OF GEORGIA
06'
05'
04'
03'
49°02'
123°57
56
55
54
53
52
51
50
49
48

Legend

Shoreline Classification

Bedrock cliff
Rock platform
Mixed sediment
Sand
Tidal flats
Sequence of rocky headlands and pocket beaches
Man-made

Access

Docking facility
Launch ramp
Staging area
Float plane landing
Helicopter pad
Marine Access

Resource Material

Hydro charts 3450
Topo maps 92 G/2
Video tape 1

Countermeasures

Oil spill package
Boom deployment metres (m)
Sacrificial beach
Oil collection point
Oil burning site
Oil disposal site

Operational Map 9 - Boundary Bay (east to Ocean Park)

Spill Response

The eastern portion of Boundary Bay is shallow and relatively protected from wind and wave action. Containment and clean-up tactics must be designed with these conditions in mind. Booms must be deployed with shallow draft vessels, and most skimming operations would favor small portable equipment. Only in the deeper waters off Ocean Park would large skimmers be able to operate effectively and safely. At low tide approximately 75% of the bay dewaters and is exposed.

Protection

Most of this operational area is considered highly sensitive. The deeper water off Ocean Park is the best site to concentrate containment and recovery operations, using booms and skimmers designed for open water conditions.

Special public sensitivities include Crescent Beach where important recreational areas are located. Inside of Blackie Spit near the mouth of the Nicomekl River the marina would require booming and possibly the limiting of access of small boats during clean-up.

Clean-up

The shorelines in this operational area are composed of tidal flats, with sand predominating along the high tide areas from near the mouth of the Serpentine

River south past Crescent Beach. Some mixed sediment shorelines occur from here south to Ocean Park. For most of the tidal flats, under low water conditions, low pressure flushing offers a good strategy to keep oil from stranding on the flats and percolating into sediments. Such an operation would have to be coordinated with the skimming operations, so that oil dislodged by flushing is quickly skimmed off. Otherwise, shoreline contamination would likely reoccur.

All clean-up operations here, as elsewhere, would take place under the advice of a government environmental expert. In a sensitive area, such as Boundary Bay, clean up operations in certain sections may be considered less environmentally sound than permitting natural cleaning. For example, shoreline clean-up in this area would likely be limited to the high tide line. Here, graders and front-end loaders may be able to operate effectively. At lower tides, substrates would not support heavy equipment. Even the activity of clean-up personnel over soft muddy substrates would be damaging environmentally, requiring close monitoring.

Access

Access for men and equipment is variable. The bluffs at Ocean Park are a local barrier, but the beaches at their base could be approached from Crescent Beach. Elsewhere, access at least to the high tide line is excellent, with protective dykes around most of eastern Boundary Bay along which traffic can pass. Below the dykes access will be largely restricted to footpassage, and traffic by clean-up personnel may be limited to sandy areas where damage during clean-up operations is relatively slight. Over muddy areas the effectiveness of foot traffic would be reduced and potentially damaging.

Access by boat would be restricted, in most areas, to high tide. However, because of possible constraints to shore based clean-up, the use of large numbers of shallow draft vessels and the deployment of small skimmers from these at high tide might offer the best possibility for cleaning the flats.

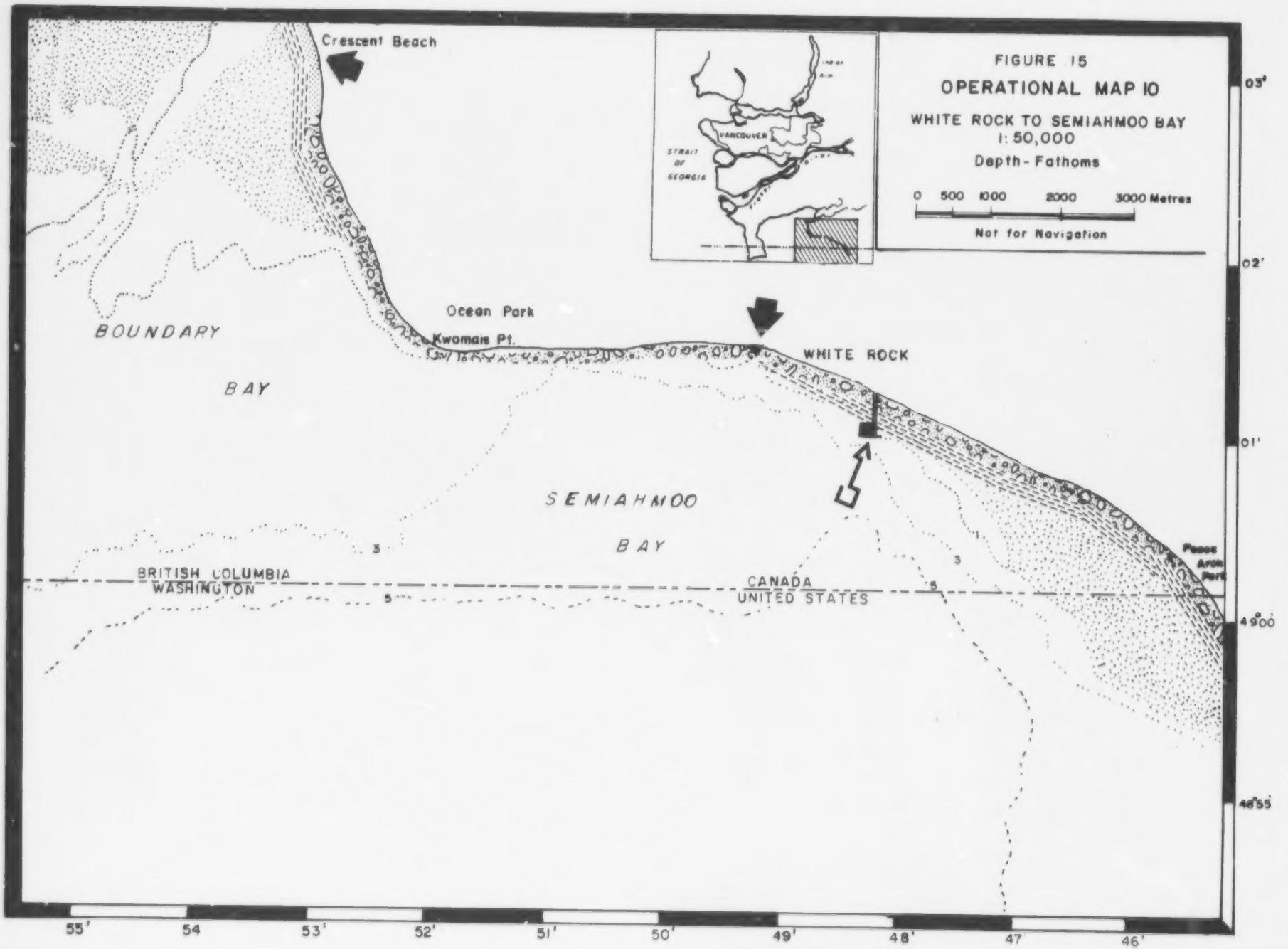
Biological Resources

Biologically, Boundary Bay is characterized by high productivity, high use by fish and wildlife, and high recreational use of these resources.

Dominating the wildlife resources are the great amount of waterfowl. Dabbling ducks (mallard, pintail, green-winged teal, and wigeon) are by far the greatest proportion of waterfowl. Though they are largely absent in the summer, migrants start to arrive in September with numbers peaking in November at over 40,000 for the entire Boundary Bay. Large numbers spend the winter and occur until April. Their distribution is characterized by proximity to the waterline, which varies with the tide, for much of the day; though they roost in deeper waters or fly into farmers' fields on a regular basis. During freezing weather, ice tends to concentrate in Mud Bay at the mouths of the Serpentine and Nicomekl rivers. Diving ducks are much less common, but they are found throughout the year with peak numbers occuring in September. Shorebirds occur most of the year, June is the exception, with August the peak period in terms of instantaneous numbers, and volume of migrants passing through.

There is a major gull roost (over ten thousand birds) located in the deeper waters of Boundary Bay, mostly from September to April. Gulls, herons, and various raptors occur along the foreshore. Most are less vulnerable to oil than waterfowl, but the effect of a spill would at least mean a temporary loss of habitat. In deeper waters, various fish-eating birds, such as loons, grebes, and cormorants are common, particularly during the September to April period.

Harbour seals are frequently found in Boundary Bay.


Crescent Beach
VANCOUVER
STRAIT OF GEORGIA
FIGURE 15
OPERATIONAL MAP 10
WHITE ROCK TO SEMIAHMOO BAY
1: 50,000
Depth - Fathoms
0 500 1000 2000 3000 Metres
Not for Navigation
Ocean Park
Kwomais Pt.
WHITE ROCK
BOUNDARY
BAY
SEMIAHMOO
BAY
BRITISH COLUMBIA
WASHINGTON
CANADA
UNITED STATES
Peace Arch Park
03'
02'
01'
49°00'
46°55'
55'
54
53'
52'
51'
50'
49'
48'
47
46'

Legend

Shoreline Classification

Bedrock cliff

Rock platform

Mixed sediment

Sand

Tidal flats

Sequence of rocky headlands and pocket beaches

Man-made

Access

Docking facility

Launch ramp

Staging area

Float plane landing

Helicopter pad

Marine Access

Resource Material

Hydro charts 3450

Topo maps 92 G/2

Video tape 1

Countermeasures

Oil spill package

Boom deployment metres (m)

Sacrificial beach

Oil collection point

Oil burning site

Oil disposal site

Operational Map 10 - Ocean Park to Peace Arch Park

Spill Response

Offshore response should concentrate on containment and recovery of slicks before they come ashore. Two important limitations must be considered however. During much of the year, but predominantly in late fall, winter and early spring, south-easterly winds blow into the Boundary Bay/White Rock area sometimes creating large swells and breaking waves, making both ocean and beach based operations difficult. Second, offshore operations would require the cooperation and support of United States agencies, particularly the U.S. Coast Guard. If a slick cannot be contained and threatens the shoreline, diversion onto sacrificial beaches may be necessary. Due to sediment type and accessibility, Crescent Beach particularly the south part towards Ocean Park seems the best choice as it exhibits fine-grained, even sand that can either be cleaned, or removed and replaced with similar sediment. An alternate choice might be the beaches immediately east of the White Rock pier. The surrounding shoreline is composed of fine mud and silt some mixed sediments and gravel, both of which are extremely hard to clean and/or replace. Crescent Beach and White Rock are both residential areas and high use recreational areas, especially in summer, and use of these beach as oil collection points would require a high level of public consultation.

Protection

The first line of protection for this area is containment and recovery operations offshore of the beaches and mudflats. A second step is to divert oil away from

mudflats toward beaches where clean-up would be more feasible. The Semiahmoo Bay mudflats provide recreational potential in summer, and are a stop-over and moulting area for many migratory birds from October to April.

Clean-up

The shorelines between Ocean Park and Peace Arch Park are composed primarily of fine-grained sands, mixed sediments, and sand/mudflats. Ecological sensitivities preclude intensive cleaning of mudflats. Low pressure flushing is a gentle technique designed to lift off oil, direct it away from sensitive areas to oil recovery equipment nearby. Should oil threaten the sand beaches preparations should be made to construct a ditch-dyke system and/or apply sorbent pads generously in the appropriate locations. Recovery operations could rely heavily on equipment near the high tide level on sandy beaches with only minor ecological considerations compared to mudflats.

Access

Land access to the area is relatively good. Roads parallel the beach for much of its length, but toward Ocean Park access deteriorates. However, the beach is flat and wide, and its bearing capacity should be sufficient to permit the use of balloon-tyred vehicles. The use of tracked vehicles over contaminated sand should be discouraged to avoid grinding oil into beach sediments.

Access for shallow draft boats also is very good, as this is a shallow bay that is exposed at low tide. At times, wind conditions from the south-east may make conditions unfavorable for small unstable craft, and make deployment of booms from boats difficult.

White Rock is a Canadian port of entry and customs clearance for U.S. vessels entering Canadian waters or Canadian craft re-entering is required. A public wharf is situated at the end of the long jetty extending south across the foreshore. The float on the east side of the jetty is used by seaplanes and small craft making customs entry. Additional floats and a fuel pump are situated on the west-side. All are protected by breakwaters and have approximately 4 m (13 feet) draught alongside. A boat launching ramp is located near the public float.

In calm weather seaplanes land regularly and there are several helicopter landing sites.

Biological Resources

The little Campbell River enters Semiahmoo Bay at White Rock. It provides spawning habitat for coho, and small runs of chinook and chum. The bay is likely utilized during spring and summer by rearing juvenile salmon.

The Semiahmoo mudflats do not compare in extent to those in Boundary Bay, but though the scale is much reduced, there are significant bivalve and crab populations.

Ducks, divers, gulls, and shorebirds are numerous, primarily from October to April in the case of ducks and divers. Gulls occur year round and peak numbers of shorebirds tend to occur in August.

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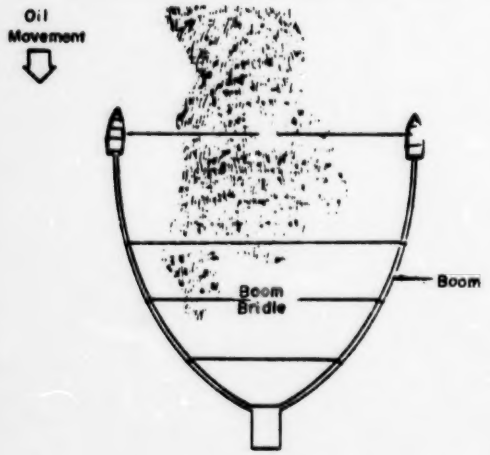
APPENDIX

Spill Response and Protection Techniques

1. Offshore Containment and Recovery

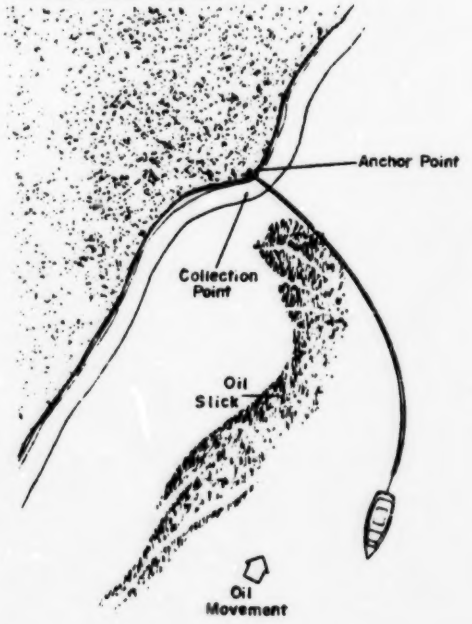


Boom deployed around oil, oil is removed from water surfaces.

Useful where current > 0.5 c/s.

Not applicable for large slicks

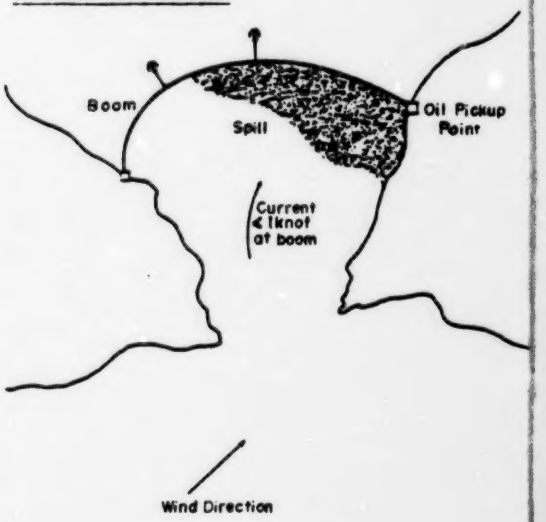
2. Diversion Booming



Boom deployed at an angle to approaching oil to divert oil away from sensitive areas. Oil is then removed from water surfaces.

Applicable where currents > 0.5 m/s and wave height is > 25 cm.

3. Exclusion Booms



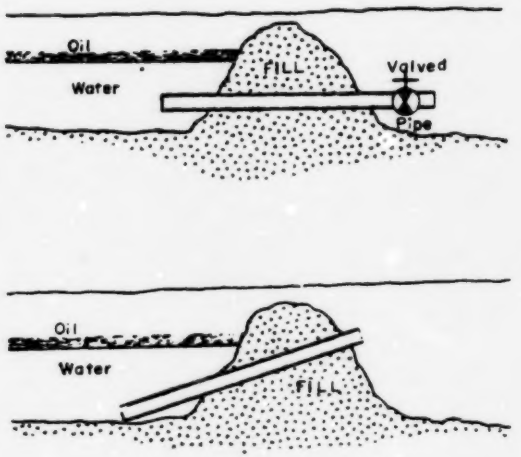
Boom deployed to exclude oil from specific areas to protect small bays, harbours, inlets or river mouths.

Applicable where currents < 0.5 m/s, wave height < 25 cm.

4. Cascading Boom Deployment

Diversion booming where little or no surf is present. Two or more booms are used to deflect the oil onto the shoreline. This method is preferred for high currents (> 1.5 knots) as stress on the booms is reduced.

5. Earthworks/Damming



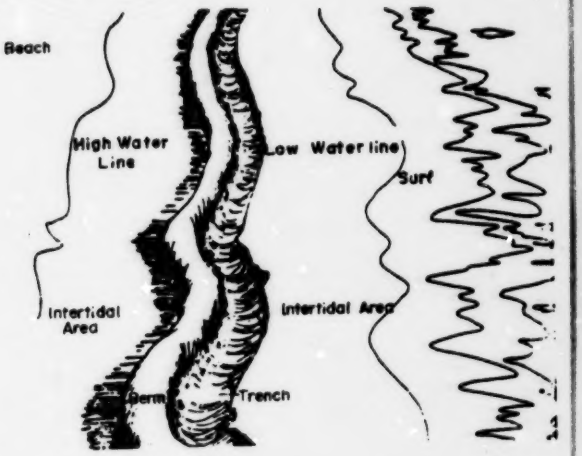
A. Valved Pipe

Water flow of stream or surface water drainage is bypassed to maintain reservoir level. Oil is skimmed off or absorbed as conditions dictate. Crest of dam should be of sufficient width to accomodate compaction vehicle. Height of fill is 0.7 or 1 m. above fluid level. Normal fall angle of fill will suffice for sloping.

B. Inclined Tube

Water flow or stream is bypassed to maintain resevoir level.
Elevate discharge and of tube(s) to desired resevoir level.

6. Ditch/Dyke System

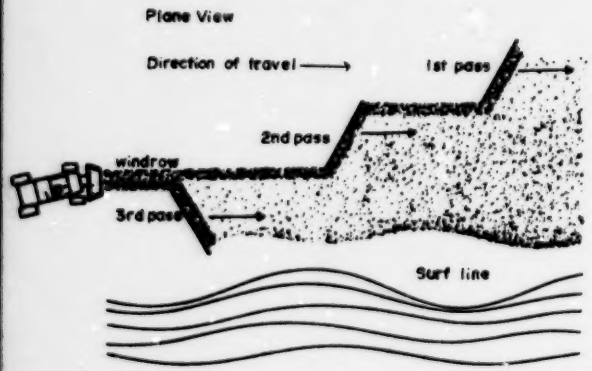


Method used on sandy or gravel low energy beaches to protect the upper inter tidal and back-shore area from oil contamination.

Especially useful during spring tides and storm surges when water level extends above normal high-tide levels for a short period of time.

Clean Up Techniques

1. Graders/Front End Loaders

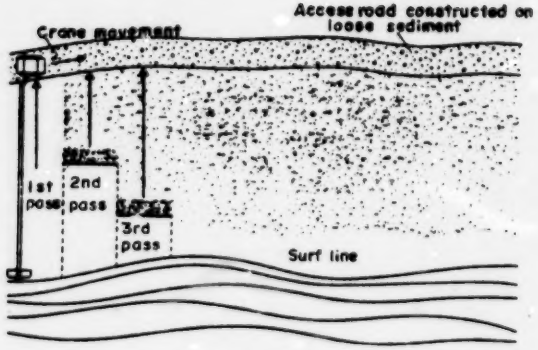


Motor grader forms windrows for pick up by front end loader.

Used on gravel and sand beaches where oil penetration is less than 2 to 3 cm.

Can be used on mud flats. Removes only upper 3 cm of the beach.

2. Clamshell/Dragline



Operates from top of contaminated area to remove oiled sediments.

Used on sand, gravel, or cobble beaches where trafficability is very poor and oil contamination is extensive.

3. Sorbents

applied manually to areas. Used to remove contaminated pools of light non-stocky oil from mud boulders, rock, and man made structure:

4. Low Pressure Flushing

Low pressure water spray flushes light non-sticky oils from substrates where it is channeled to recovery points.

5. Hydroblasting

High pressure water streams remove oil from substrate where it is channeled to recovery area.

6. Steam Cleaning

Steam removes oil from substrate where it is channeled to recovery area.

7. Sand Blasting

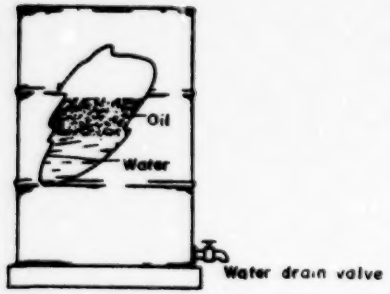
Sand moving at high velocity removes thin accumulations of oil residue from man made structures.

8. Manual Scraping

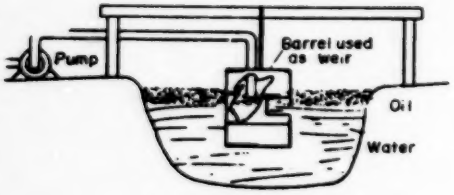
Oil is scraped from substrate using hand tools. Used to remove oil from substrate when other techniques not allowed.

7. Oil/Water Separators

A.



B.

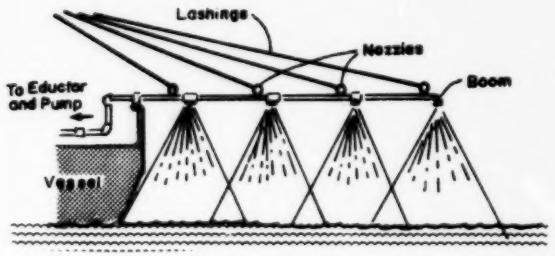


Most oil/water separation can be performed at refineries or oil production sites. With a minor spill, or one far from such a facility, field separations techniques can be utilized.

A. Oil/Water mixture enters apparatus from above. The mixture is allowed to settle and then water is drained off from the bottom.

B. Drum suspended into sump pit, positioned so that the bottom of the slot cut in the drum is just below the oil surface. Oil flows into the drum and is pumped into a storage tank.

8. Chemical Dispersion



Experimental Dispersants sprayed directly on the water to facilitate the 2 or 3 dimensional breakup and dispersion of the slick.

Requires permission of regulatory agencies.

Light to medium fluid oils. Best suited in areas where natural dilution rate of dispersed oil is great.